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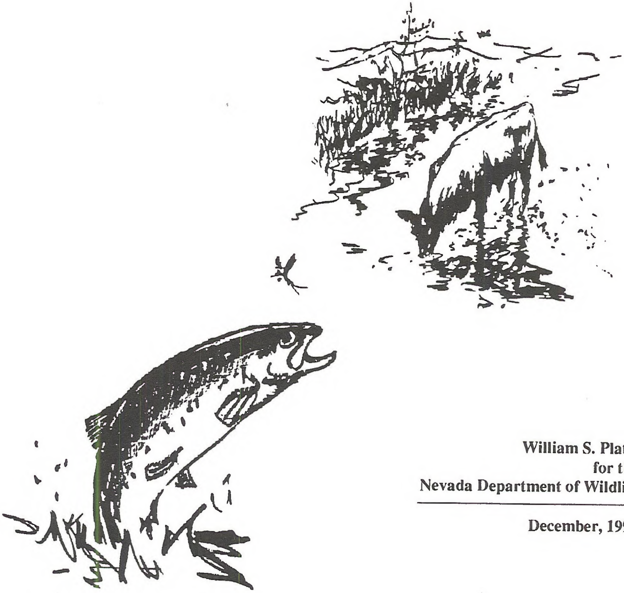
MANAGING FISHERIES AND WILDLIFE ON RANGELANDS GRAZED BY LIVESTOCK

A GUIDANCE AND REFERENCE DOCUMENT FOR BIOLOGISTS



William S. Platts
for the
Nevada Department of Wildlife

December, 1990

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INTRODUCTION

USING THIS GUIDE

The purpose of this Guidance and Reference Document is to allow biologists to more effectively participate in the management of rangeland resources. While the scope of this document is keyed mainly to the Great Basin of Nevada, much of the contents has application to the western United States, and many areas of the world. The document is large and cumbersome. Don't waste valuable time reading the complete document. It is designed so the reader does not have to spend hours reading or understanding dull models, methods, or historic accounts to make a good contribution to rangeland management. The format allows fast, easy retrieval of information needed for interpretation or decision making. Use it like a dictionary to get to needed information quickly.

First, learn the *document format* via the Table of Contents. Time is precious so get right to the nuts and bolts of what you need to review to prepare for the present day's "instantaneous calamities." Familiarization with the Table of Contents will keep you from spending hours reading chapters that you do not need to assimilate at the outset.

If I were just starting out again in riverine-riparian management, the first thing I would do is to go completely through the Glossary (p. VII-17). You will never work successfully with people until you can understand and talk *their* language. The Glossary will allow you to do this, especially if you go out and practice this language on your colleagues. Nothing stirs up interest more than being able to talk intelligently about the "bucking pasture," or the use of "feeding supplements" to gain better control over livestock distribution.

ONCE DETERIORATED, RIPARIAN HABITATS ARE DIFFICULT TO REHABILITATE UNDER MOST LAND USE PRACTICES

Once the Glossary is under control, I would review the legal mandates so you know what the people you work with have to abide by. A good understanding of how the citizens of the United States want their lands to be managed is a must. Also, at this time "speed read" the Issue Scope section (p. I-12) to develop a feeling for the livestock industry. This is a very valuable component of our social and economic structure. Management must provide for its prosperity as well as proper stewardship of the rangelands. The livestock operator actually has more to gain under good rangeland management than we do as biologists. His well being is our well being.

The Historic and Present sections will tell you where we have been and where we are. This is a must if we are to have an intelligent understanding and feel for where we should go. Other sections will tell you how to get there.

WE HAVE TO WORK SMARTER -- NOT HARDER

At this point, so I could act the part of a competent biologist, I would do some fine tuning. I would brush up on the Riverine-Riparian Ecology section and the habitat requirements of fish. The sub-section on the FISH-SED Model (p. IV-48) has excellent coverage of habitat conditions that affect salmonid populations. These include winter and summer requirements. The effects of fine sediments in redds and pools. The effects of predation. The effects of channel embeddedness on winter and summer rearing conditions and pool quality. These can be reviewed any time for a quick refresher course in habitat requirements.

The section on Inventory and Monitoring (p. VI-1) is *state-of-the-art*. This will give you an understanding of streambank mechanics that few people have. Because streamflows are so important in Nevada and their diversion to irrigate pasture lands for livestock is so widespread, I would review the section on determining and evaluating streamflows (p. VI-36). This is especially needed if you are presently hung up on IFIM instream flow methodology. You will find that this flow model will not only to keep fish wet but justify flows for habitat needs. An important point in fish-wildlife management is to provide processes to maintain valleys and riverine-riparian areas. To tunnel your thinking down to "wetted unit area" can slight real resource needs.

The next thing I would do is review the Case Histories section (p. III-50). This will develop an understanding of how your co-workers have accomplished some good things. I would then go beyond the Case Histories and in the References (p. VII-1) and Suggested Reading (p. VII-39) sections, review the works of Wayne Elmore, Lew Meyers, William S. Platts, Bob Phister, Bruce Smith, Anne Sands, Roy Johnson, and Boone Kauthman. These authors have waded a lot of creeks and herded some cows.

Nevada makes up the main part of the Great Basin - a huge expanse of desert landscape with no drainage to the sea. Climatic conditions vary with elevation, with mesic conditions at higher altitudes and xeric conditions at lower altitudes. Winter moisture in the form of snow along with some seasonal rains feeds mountain streams that eventually empty into low playa lakes. Perennial streams are usually small and often go dry in their lower reaches. As the summer season advances streams often go dry from agricultural diversions and because water tables have been lowered by mismanagement.

WITH PROPER STRATEGIES, CONTROLLED INTENSITIES, AND ANIMAL DISTRIBUTION, LIVESTOCK GRAZING OF RIVERINE-RIPARIAN ECOSYSTEMS IS COMPATIBLE WITH OTHER RESOURCES

Before Europeans immigrated into the Great Basin, natural ecosystems existed under grazing by insects, small mammals, and wild ungulates. If forage became scarce or nonexistent, animals either moved to more favorable ranges or perished, thus always bringing populations into balance with range capacity.

The early settlers in the Great Basin recognized that the vast rangelands could be used for livestock grazing to provide food and money. At first they could not comprehend that the new rangeland produced product (livestock) would later cause the demise of other range resources. The heavy grazing that took place altered natural ecosystems, and especially the riverine-riparian system. Many of these systems no longer bear any resemblance to their historic habitat condition.

A tremendous awakening has occurred in the last decade towards an appreciation of the many valuable resources the riverine-riparian system can produce. The growing recognition that these areas have fish and wildlife has lead to close scrutiny of how they are being managed. Most Nevada citizens float rivers, fish, hunt, and swim all of which demand a quality environment. This quality is only attained or maintained under good rangeland management.

Many streams within the Great Basin and along the Eastern Sierras are now in poor condition (BLM 1974). They attained this condition partly because many small annual degrading effects accumulated to where they now constitute major changes. Nevada streams reflect a century of these cumulative effects. These impacts are occurring on streams and wetlands that are unique to the remainder of North America. Salinity in these aquatic systems can be extreme. High rates of evaporation and transpiration occur. When water does accumulate it is as productive for fish and wildlife as any other water found within the United States.

Many studies and experiences have demonstrated that improperly managed grazing animals can damage riparian-stream habitats. Livestock operations have dominated the use of most rangelands over the past century. It has been well demonstrated that solutions to past and on-going grazing problems are not easily found. To compound today's problem, land managers not only must administer their own grazing management program properly, but they must also correct damages produced by the heavy grazing of the past.

Range and wildlife-fisheries managers are presently making complicated and hurried decisions, often without the benefit of adequate knowledge or experience. The purpose of this guidance document is to provide the information and experience necessary to uncomplicate decision making. The document will allow decisions to be made at a fast pace, as is necessary in a fast world.

Land management actions that lead to environmental impacts have political, social, and economic implications. The combination leads to issues that if not solved evolve into problems. Any loss of fish and wildlife or ranch income means problems that need solutions. The pathway to a solution requires that we first look at the suitability of the rangeland for grazing. If suitable, what class and kind of animal is best suited to harvest the forage? What grazing strategy is compatible with all the other resources? Most importantly, how do we implement the management of this strategy?

The solution to good rangeland management is certainly not to argue whether livestock grazing degrades stream-riparian systems. The solution is to apply management strategies that build compatibility with all resources. From the perspective of future generations the actual rate of riverine-riparian recovery is relatively unimportant. What will be important to them is whether we start the rehabilitation now or leave it up to them. Some of us short-timers, however, want to see action now so we can also share in the enhanced products.

TO PROTECT YOUR RIVERS, PROTECT YOUR MOUNTAINS

- EMPEROR YU OF CHINA, 1600 B.C.

Then I would place this document on the shelf and get on to more important things. I would pare down the paper that has us all bogged down and spend more time on the ground getting dirty and sweaty. Listen carefully to the problems of permittees and land managers.

There is only one thing worse than a biologist who is *not* getting "dirty" on the ground with those people he or she must work with. This is the biologist who is so busy in the office he cannot go out and live with a cutthroat trout or a great horned owl.

THOSE INVOLVED IN THE MANAGEMENT OF AN AREA MUST UNDERSTAND AND AGREE ON THE OBJECTIVES AND THE SOLUTION TO THE PROBLEM

You must continue to have the feel for slime, scales, and feathers. If you do not it puts you in the same category as a livestock operator who no longer deals in manure, dust, rain, and cold. If livestock operators hadn't lived in the field they would no longer be in business. Take some pointers from these hard-working people who have developed a feel for the land. The needs of fish and wildlife only have to be included in their thought processes.

The document format not only serves as a learning instrument, but more importantly as a day-to-day reference manual. The document begins with a brief discussion on the historic, the present, and future scope of the problem. The legal mandates are intensively covered so the user knows what the land manager and the operator are required to do. The remainder of the document is structured so the user does not have to completely understand or mentally retain much of anything. The document serves as a quick reference and refresher for day-to-day operations. If, for example, you are suddenly called to a meeting, a quick field inspection of an allotment, or to give testimony on a allotment management plan, you can quickly get up to speed.

BE FLEXIBLE IN MAKING NEEDED ADJUSTMENTS IN GRAZING MANAGEMENT

If the allotment plan under review states that season-long grazing is the strategy being used, then you can brief the section on Grazing Strategy Definitions and Interpretations (p. II-1), which will provide background on what this strategy is all about. The section covering grazing strategy compatibility (p. II-25) identifies problems to watch out for. It lists why the strategy may or may not work. Suggestions for alternative approaches to management are given. The user does not have to laboriously read through these large sections, just through those sub-components that deal with season- long continuous grazing.

If the lead decision agency is the BLM, then a quick review of the section on "Procedures For Working With the BLM" (p. III-24) can make you much more effective. Also, this would be an opportune time to quickly review how to work with the BLM in allotment management. Finally the user should be in position to suggest different ideas, methods, or alternatives to what the agency is recommending. Most rangeland plans now in use are not working in riverine-riparian systems. The user can review the inventory methods available and the models that will predict consequences if a proposed plan is carried out.

A solution to the problem is usually available in the sections on grazing strategy compatibility and case histories. A couple different strategies can be reviewed as proposed alternatives to one being used or proposed.

If progress is to be made in rehabilitating western streams, rangeland management has to be improved greatly over that being practiced today. This document is dedicated to seeing that the biologist has the tools, background, methods, and input necessary to turn this situation around. If present knowledge were only put on the ground, western streams could rehabilitate quite rapidly. Your responsibility is to do just that.

Many individuals and organizations are advocating either the reduction of livestock numbers or removing them from the rangelands altogether. This is not the solution and we should no longer look back on the past and assign blame. Past practices, even though some were destructive, gave us part of the lifestyle we now enjoy. The mistakes of the past provide a learning foundation for progress. The lifestyle of the future will be even better. I firmly believe that today we have the knowledge required to quickly move into good rangeland management. We only have to apply what we know.

LIVESTOCK IMPACTS

Ninety-one percent of the total public and private rangeland is grazed in the West (720 million acres). In Nevada it is even higher than this. Proper grazing of these rangelands is compatible with riverine-riparian systems and there are many case histories to document this. There are however, many case histories documenting the impacts of improper grazing and this chapter deals with these types of impacts.

Uncontrolled, unregulated or unplanned livestock use is occurring in approximately 85 percent of the State of Nevada and damage to wildlife (fisheries included) can be described as extreme destruction (BLM 1974). The report states that 883 miles of BLM streams were identified as having deteriorated and declining habitat. In the past decade many of these streams could have come under better management, but as the GAO (1988) report documents, conditions are still in need of repair.

Hormay (1970) estimated that grazing capacity for livestock has been reduced by half or more on western ranges. So it isn't only the wildlife and fisheries values that are being depressed, it is also the "red meat" industry itself that can benefit from improved rangeland management.

Improper livestock grazing can affect all four components of the riverine-riparian system -- the channel, the streambanks, the water column, and the in-stream and bordering vegetation.

> ***WE CANNOT ARGUE THE FACT THAT THESE VITAL LANDS ARE DETERIORATING --- WE CANNOT ARGUE WITH THE ENVIRONMENTALIST THAT THE NUMBER OF LIVESTOCK HAS TO BE REDUCED IF WE ACCEPT CURRENT CONVENTIONAL RANGE MANAGEMENT***
>
> **- THE SAVORY LETTER**
> **1983**

Vegetation

Streamside vegetation is more affected by grazing than upland vegetation. Riparian areas are usually grazed more heavily than the adjacent uplands (Platts and Nelson 1985). The vegetation problem is further complicated because most of today's range management guidelines do not differentiate grazing strategies between the riparian and the uplands. When riparian areas are lumped into the broad allotment boundaries, they become unidentifiable for land management purposes.

Improper grazing can reduce vigor and alter, reduce, or eliminate streamside vegetation (Knoph and Cannon 1982). This in turn can change plant species composition, lower water tables, change the timing and amount of organic energy entering and leaving the stream, decrease canopy cover, and change a stream from a perennial to an ephemeral condition. Livestock directly alter streamside vegetation by trampling, rubbing, and grazing on herbaceous plants and browsing on shrubs. Browsing on shrubs can alter the size, shape, spacing, and especially the numbers of woody vegetation. Usually the narrower the riparian zone, the more easily this zone is altered by grazing.

Environmental changes from grazing are usually small from year to year and often go unnoticed. They are, however, cumulative, and over long time periods build into major changes. Whether a riverine-riparian area has suffered a sudden major catastrophic event, such as a mine tailings pond wash-out, or a long series of small annual cumulative events, the results for fish and wildlife can be the same.

The vegetation composition can be changed relatively quickly in a matter of only a few years by improper grazing (Hormay 1970). Ranges are deteriorated because plants are killed (Hormay 1970). A prime example of changes resulting from killed plants, is the replacement of native bunch-grasses and sedges with Kentucky bluegrass. This is a very common occurrence in Nevada. The other major change that has taken place in plant species composition is the past conversions from brushy riparian species to grasses and forbes. This is a significant conversion because of the resulting effects on fish and wildlife.

In most valley bottom types where sedges can become the dominant understory, they clearly create the most optimal streambank structure. Even under grazed conditions, some of the optimum bank characteristics are associated with this community type. Thus, moderate grazing pressure after viable sedge communities have become re-established may be acceptable. Managers, however, must ensure that CAREX community types do not revert to less favorable communities like Kentucky bluegrass.

Gifford (1976), however, states that composition is not nearly as important as are changes in watershed protective cover. Gifford backs this statement by documenting changes that develop in soil erosion. Grazing may also influence community succession (Gifford 1976). These succession changes are pronounced under severe grazing and in some instances difficult to distinguish at light or moderate levels (Ellison 1960).

Streambanks

Livestock grazing effects on streambanks occur mainly in two related categories - the removal of bank vegetation or change in species composition, or trampling and shearing banks themselves. As discussed in the section on vegetation, the roots stabilize streambank soils and the above-ground stems and leaves dissipate the energies of water, ice, and wind, to reduce streambank erosion. Adjusting the length of the grazing period will do little to alter the level of trampling damage. The susceptibility of banks to trampling damage is a function of sod moisture content rather than the number of cattle using the area. (Marlow and Pogacnik 1986). Heavy trampling compacts soils in the uplands and reduces infiltration. This increases storm flow runoff and in turn peak flow discharges. Soil compaction also occurs in the riparian zone. The most significant factor, howver, is streambank trampling. This causes streambanks to slough off, creating false setback banks and exposing the trampled banks to accelerated soil erosion.

Livestock are drawn to riparian areas. The overall effect is bank destabilization. This causes adjustments in bank angle, channel and water column shape, reduction of streambank undercuts, and changes in sediment loads and water discharge. Stream-channel sedimentation caused by soil erosion on millions of acres of rangelands has long been recognized as a major watershed-fisheries problem (Lusby 1979).

When cattle graze good condition riparian areas in an overstocked condition with poor timing, impacts to the riverine-riparian area will usually always show up first on the streambanks. This is the prime reason it is so important to work streambank condition into field inspections or monitoring projects.

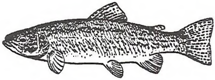
Fisheries Habitat

The most apparent effects on fish habitat are the alteration of streambanks, reduction of shade, decrease in cover, and subsequent changes in stream temperatures. In general when improper grazing ceases the stream channel narrows and deepens, pool development is accelerated and streambanks stabilize. Generally, streams in improperly grazed areas contain more fine sediment, streambanks are more unstable, banks are less undercut, and channels have widened. What usually goes unnoticed is the subtle change in the timing and magnitude of stream flows. Along with changes in channel form, this can cause increases in stream width and decreases in stream depth. Channel morphology can be changed by accrual of sediment. This causes alteration of the channel substrate, which in turn causes changes in pool shape and size.

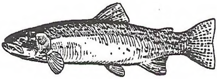
The water column can be changed by altering nutrients, suspended sediment, and bacterial populations. The most significant, however, other than change in channel and water column morphology, is the change in water temperatures. Direct solar energy is the principal source of heat to small streams. Removal of vegetative cover or widening of the water column may result in significant changes in summer stream water temperatures. Elimination of overhead cover may also affect stream winter temperatures. This allows heat to leave the system to the atmosphere, thus decreasing already cold temperatures and causing more icing conditions. Reduced streamside cover may also affect intragravel water temperatures. Ringler and Hall (1975) found that both the mean temperature and diel fluctuation within the gravel increased in relation to reduced cover.

Dissolved oxygen, like water temperature, is a primary regulator of biological activity in the aquatic ecosystem. Dissolved oxygen in a stream is a function of water temperature and channel characteristics. Thus, any practice that increases stream temperature decreases stream dissolved oxygen levels. There is insufficient information available in Nevada streams to determine whether or not this is a problem.

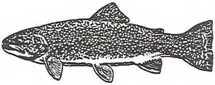
Cover and good quality water are crucial for fish health and survival. Water cannot be too warm nor too cold. It must be fertile but not over-fertile. Velocities cannot be too fast or too slow. Water must contain the right amount of dissolved gasses. Generally streams in grazed areas contain more fine sediment, streambanks are more unstable, banks are less undercut, and summer water temperatures are higher than those of ungrazed streams (Armour 1977, Behnke and Zarn 1976). Behnke and Zarn also state that livestock grazing the vegetative streambank cover and caving in overhanging streambanks is one of the principal factors contributing to the decline of native trout in western streams.

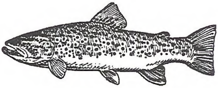


The alteration of streambanks is crucial as streambanks bordering streams provide the habitat edge needed to maintain high fish population densities. Fish often adapt their survival to this habitat edge because streambanks provide cover, control water velocities, and supply incoming terrestrial foods. The streambank condition often governs the water depths and velocities in which the fish must live.



High temperatures from the removal of streamside vegetation can be acutely lethal. Disease can be promoted because of induced stress. Spawning and reproductive success can be adversely impacted. High stream temperatures can slow growth and stop fish migrations. If sediment and turbidity are increased then primary productivity is decreased. Aquatic insect food production is then reduced. The increased sediments hinder the emergence of alevins in the gravels, decrease winter area survival by filling in channel pore spaces and reducing the channel's potential to produce food.





ISSUE SCOPE

HISTORIC

Prior to the Turn of the Century

Prior to the 1900's western rangelands were occupied by Indians who were gatherers and hunters. The Great Basin and the Eastern Sierras were probably lightly grazed by deer, bighorn sheep, and pronghorn antelope. The major grazing, however, was by insects and small mammals. Wild ungulates probably grazed the Great Basin in low numbers. Young et al. (1976) report that pronghorn antelope populations were not high enough to support drives by the Deep Creek Goshute Indians more frequently than once a decade.

The impression that Great Basin ranges were driven to the pre-contact condition by the heavy grazing of wild ungulates does not hold. The sparse population of large ungulates such as bison may have resulted from the arid summers, cold snowy winters, desert shrub-steppe vegetation more suitable to selective-type grazers, and unstable hydro-geologic forces (Platou and Tueller 1985).

THERE IS PERHAPS NO DARKER CHAPTER NOR GREATER TRAGEDY IN THE HISTORY OF LAND USE IN THE UNITED STATES THAN THE STORY OF THE WESTERN RANGE

- REPORT ON THE WESTERN RANGE, 1936

The main influence of the Indian on the native vegetation was through the use of fire as an aid in hunting or comfort. They had insignificant influence on riverine-riparian systems.

It was about 1840 that the ability of the Great Basin's ranges to support large numbers of livestock became recognized. The immense "seas of grasses" found in most areas were soon being consumed by sheep and cattle (Cottom 1961). In the beginning, few considered that the Great Basin in its immensity could not continue forever to support all the livestock that could be introduced.

The growth of the livestock industry exploded in the early 1870's and within a decade both cattle and sheep had reached peak numbers on most western ranges and the range exploitation began. Within a brief span of 25 years (1875 to 1900), the once-empty rangelands of the Great Basin had been overfilled with domestic livestock. The introduction of livestock had more effect on the Great Basin environment than any other event in at least the previous 1,000 years (Davis 1977).

Where ranges were heavily stocked, changes in vegetation took place. Livestock trampled and compacted the soil. The high-quality, fibrous-rooted plants gradually gave way to shallow-rooted annual species, tap rooted forbs, or shrubs that could exist on areas with lowered water tables.

The number of animals occupying the available range increased far beyond its carrying capacity. In the 17 western states, cattle numbers increased from 7.9 million in 1870 to 22 million in 1886, a period of only 16 years. Year-around grazing on open range was the common strategy. This met head on with severe summer droughts in 1891 and 1892, and the severe winters just prior to the turn of the century. Massive die-offs severely reduced the numbers of livestock. They soon increased in numbers when operators went to a season-long continuous grazing strategy that required supplemental feeding during winter periods. This strategy is still commonly used today, almost a century later. Rangeland abuses were reported as early as 1862 and continue today. Government intervention into grazing problems on the western range began in 1898 when the Department of Interior granted grazing permits to limit the number of livestock on federal lands.

After the Turn of the Century

After the turn of the century, livestock owners and managers formed associations to help resolve the chaos of the 1870's. The system of free access with unrestricted grazing was ending. In 1905 the U.S. Forest Service was established and the process for forage allocation began. After 80 years, however, the Forest Service has not been able to get many western ranges back on track. The riverine-riparian systems are still deteriorating. By 1915 range specialists (Frederick Clements) were recommending that livestock numbers be reduced, certain ranges be rested, and deteriorated ranges be reseeded. Seventy-five years later this thinking still is prevalent. Because the price of cattle was very high during World War 1, grazing management was completely set back by severe overgrazing form 1915 through 1920.

The 1930's to the 1970's

A major effort in livestock management was made in the 1930's by the passage of the Taylor Grazing Act (1934). This Act had the practical effect of turning over livestock access to the public lands to the more wealthy of the livestock operators who had the private land and water base tied up. The Act placed the administration of the remaining public lands under the U.S. Grazing Service, later to become the Bureau of Land Management in 1946. The Act's main purpose was range rehabilitation.

THE OPEN SYSTEM OF GRAZING LIVESTOCK THAT WAS SO DAMAGING WAS GRADUALLY GIVING WAY TO MORE HUMANE AND EFFICIENT METHODS

This Act was intended to reverse the downward trend on rangeland condition, but little attempt was made to control grazing and the detrimental effects continued to occur. From the 1930's to the 1970's, however, resource managers did initiate improved programs for grazing (Busby and Gifford 1978). Johnson (1965) and Hormay (1970) were demonstrating that rest-rotation grazing could benefit range conditions.

As interest in environmental quality and fish and wildlife grew in the 1960's, a new militant conservation movement arose that ultimately produced the National Environmental Policy Act. The new environmental movement, unlike the one that created the Forest Service, now was suspicious of the Forest Service and other governmental agencies with obvious leanings towards special interest users of the wood and forage.

By the mid-1960's management by allotment (designated areas that fit the needs of the livestock operator to successfully graze animals) had become an accepted practice on public lands, and remains so today. During this same period the multiple use concept developed. Wildlife, water, watershed values and recreation became recognized as important rangeland products as well as range. A lot more interest in the public rangelands developed in the form of outright opposition to livestock grazing on public lands and/or concern for the way livestock grazing was or was not being managed on the public's lands.

For the first time in the 1970's, the importance of riverine-riparian systems to wildlife and fisheries had become so apparent that the public became interested. In response, the U.S. Forest Service and the Bureau of Land Management, along with private range owners, initiated improved grazing practices and the ranges began to improve. The agencies needed some prodding to make the necessary changes. For example the BLM attempted to slide by with a "programmatic" environmental impact statement that covered all the nation's grazing. The public did not let them get away with it and they were instructed by the courts to consider local environments in their impact statements.

The National Environmental Policy Act was written in response to the sudden swell of emotion over environmental quality. It became the driving document for change in the 1970's. It's impact is well demonstrated by the 1973 suit by the Natural Resource Defense Council against the Bureau of Land Management that forced the Bureau to prepare EIS's on the issuance of grazing licenses. This decision flew in the face of those who still maintained the maximum economic return in rangeland management was producing "red meat."

In 1976, the Congress sought again to change the philosophy that the public's lands were only for the mismanagement of livestock grazing. They enacted the landmark Federal Land Policy and Management Act. This act established the policy that public lands were to be retained in federal ownership and that their deteriorated condition should be improved. It is interesting that in the Federal Acts Congress discusses range and not forage. The failure of Congress to even specify grazing as a major use buttresses the conclusion that livestock operators and rangeland managers were not to give priority to livestock grazing. They were not to receive exclusive range use. The new planning mandates gave clear direction to the BLM and the Forest Service that in the future their task would demand concerted actions and policy changes if they were ever again to get the public off their backs.

THREE-FOURTHS OF THE WESTERN RANGES ARE PRODUCING LESS THAN HALF OF THEIR POTENTIAL

- BOX, ET AL. 1976

The 1980's

The 1980's brought in the "riparian period," and never again would livestock grazing management be the same. The Nation became aware that its wetlands and also its riparian habitats were not only in bad shape, they were disappearing. Something drastic had to be done. The public was challenging government on its traditional position that the western rangelands were primarily for livestock production. This use is considered inconsequential when viewed in the national perspective (Attebery 1976). Governmental agencies responded but ineffectively because the environment is a complex system. Livestock impacts were cumulative, and even though they couldn't be seen annually, in the sum they were deleterious. Their review of on-going actions did not tell the complete story.

Busby (1978) stated that range conditions today are far better than the denuded, deteriorated rangelands that existed in the early 1900's. Platts (1981) contended, however, that studies leading to this conclusion were based mainly on data collected from the drier upland ranges. They usually did not take into account the still-deteriorated riverine-riparian areas. While the uplands have recovered some since 1935, the condition of riverine-riparian systems has continued to decline. The 1988 GAO report bears this out.

The main reason for the riverine-riparian systems not following upland gains is that insufficient emphasis was placed on riverine-riparian management. The emphasis was on producing forage. In the early 1980's, large storms had a major impact on Nevada's rangeland streams (Platts et al. 1985). These storms represented major hydro-geologic influences on the riverine-riparian system. The response to the high flows was exacerbated by the system's already degraded condition from historic changes. The drought years of 1987 and 1988 further compounded this problem.

Present

LIVESTOCK GRAZING IS THE GREATEST THREAT TO THE HABITAT INTEGRITY OF TROUT STREAMS IN THE WESTERN UNITED STATES

- BEHNKE AND ZARN 1976

It is mistakenly believed by many that the numbers of livestock have declined in the western United States since 1935. The numbers of sheep may have declined, but the number of cattle has increased constantly since 1875 (Wagner 1978). Currently, grazing pressure from all domestic livestock and populations of big game animals on Great Basin ranges is much greater than when Europeans first settled America (Platou and Tueller 1985, Young et al. 1976). Another factor to consider is that an average cow at the turn of the century weighed about 800 pounds, compared with 1,000 pounds today, which suggests that the forage demand has increased some 25 percent per animal (Wagner 1978).

As a result of increased forage use and changes in or eradication of natural vegetation, much rangeland has been altered (Lusby et al. 1971 and Sartz and Tolstead 1974). It is probable that stream-riparian areas are as badly deteriorated today as they have been at any other time during modern history in the Great Basin (Platts et al. 1985).

The 1989 GAO report stated again that the public's lands were not being managed properly. The needs of commercial interests such as livestock permittees were placed ahead of other users, as well as the long-term health of the resources. The 1988 GAO report shows that almost 60 percent of the grazing allotments BLM has information on are in less than satisfactory condition. Moreover, on 75 percent of the allotments threatened with overgrazing, BLM had not scheduled any action to reduce authorized grazing levels. In Nevada, two of the BLM districts reported that 93 and 86 percent of its riparian habitat was in only poor to fair condition. The Forest Service reported that in its Austin Ranger District, 90 percent of its riparian areas were in unsatisfactory condition (GAO 1988). A poor showing for the land managing agencies.

Forums, seminars, symposia, workshops, and town hall sessions have been held throughout the Nation to try and do something to eliminate the present situation. These sessions have built the awareness, but have done little to turn the degradation of riverine-riparian habitats around. With an expanding human population and the demand for "red meat" holding steady, more pressure will be placed on the rangelands for the production of more resources. Most of Nevada's rangelands were overgrazed sometime during the past 85 years, so present emphasis is mainly to protect and improve plant biomass and vigor. With stream-riparian environments badly degraded and a burning need to begin the rehabilitation, rangeland managers are caught in the middle. They are now forced, usually by political and social pressures, to rely on grazing strategies that cannot maximize goals for production of both livestock and fish. Something has to give and if good rangeland management does not come in the near future, something will give to eliminate the problem.

Today's range management guidelines are just beginning to call for different management strategies for different habitat types. The guidelines of the past covered only broad combinations of lands that mixed the riparian zones with the upland zones. The present solution is to use the compatible grazing strategies now available and get on with the job of taking care of the lands. The purpose of this document is to make sure that lack of information and understanding is not the reason the Nation's rangelands remain in such bad condition.

Future

The solution to the livestock and wildlife-fishery conflict is certainly not to argue whether livestock grazing degrades riverine-riparian zones. The solution is to identify and develop compatible grazing methods. Thus lies the future. The success of this venture will determine the tenure of livestock grazing on the public lands.

Great Basin history has well demonstrated that nothing stays static for long. Changes are sure to follow and even be accelerated under human influences. Thus, future storms will place the Great Basin and Nation's rangelands under continuous stress. Only healthy, well-managed rangelands will be able to withstand the future climatic influences without undue damage to rangeland resources.

These are encouraging times. Even though we often feel that riverine-riparian management needs are moving along at a snail's pace, rangeland management is moving ahead. The public is becoming more aware that well-conditioned rangelands will produce the much-needed resources. Multiple-use demands on rangelands will certainly continue to increase. Rehabilitation of rangelands is the most efficient way to increase wildlife and fish in Nevada.

We know enough now to bring back Nevada's riverine-riparian habitats. We only need to put our present knowledge and experience to work and match it with the needed commitment. The first step is to begin applying compatible grazing strategies that fit the needs of different types of lands. Don't make this difficult. All too often we become bogged down in attempting to cover every base, or wait years for unneeded research or inventory before taking the first step. The fisheries-wildlife profession must be willing to make recommendations now. The public has every right to expect and demand leadership from fish and wildlife professionals. We can no longer avoid this responsibility.

Where the BLM is concerned, the 1988 GAO report stated that widespread repetition of successful riparian area improvements is not likely in the foreseeable future. Even though the Forest Service and the BLM have issued riparian policy statements, the budgetary restrictions, lack of skilled staff and commitment still stand in the way. The pace of bringing back Nevada's riparian areas will depend more on commitment than any other issue.

Nevada has 7,385 miles of streams, most of them needing some type of rehabilitation. The status of these streams depends mainly on the management on federal lands because the majority run through these lands. Some of the better streams, however, run through private lands. The management agencies and private land owners are re-examining old policies and generating new ideas. As a result of their interest and understanding of the products that can come from healthy riverine-riparian systems, the future should be much brighter than the past.

RANGELAND MANAGEMENT IS MUCH BROADER THAN JUST LIVESTOCK GRAZING

RIVERINE-RIPARIAN ECOLOGY

RIVERINE STRUCTURE AND FUNCTION

Streams are diverse and highly variable geomorphic systems that are controlled by climate, geology, vegetation, and surrounding land uses. Localized control caused by beaver dam complexes, mass soil movements, colluvial boulder slides, and mechanical activity such as livestock grazing can dominate the form of individual reaches of a stream. Over geologic time periods, streams migrate back and forth over their flood plains creating valley bottom types compatible with its flows. In many of Nevada's mountain streams, however, the riverine-riparian habitat is usually shaped by external factors such as hillslope erosion processes and bedrock control of stream placement and form.

Stream-riparian habitats under natural hydro-geologic control display a wide range of conditions over long geologic periods. These habitats seldom reach equilibrium or steady states because they must adjust to constantly changing hydro-geologic factors. Its easier to work with stream processes when you visualize them as always playing "catch-up." By this I mean they are always responding to something or the combination of all things that are taking place in the watershed. The stream is always reacting to watershed control, but always in a delayed period. Often before a stream can catch up to the condition the watershed wants it to be in, the watershed changes the game plan by developing a new set of conditions to react to. A stream receiving both natural hydro-geologic and cultural impacts can change rapidly. This leads to rapid changes in the states of the streams.

THE STREAM AND ITS WATERSHED FUNCTION AS A UNIT; IF THE WATERSHED IS NOT CONDUCIVE TO GOOD STREAM CONDITIONS, THEY WILL NOT EXIST

Stream-riparian habitats can, and often do, react quickly to climatic or cultural changes. However, some changes that take place in hours or months may take years or centuries to erase. The failure to identify the watershed condition causing a stream to react has led to the demise of many stream-riparian habitats. The high precipitation years of 1983 and 1984 throughout Northern Nevada is a prime example of this cause and effect with delayed response.

Climatic variability and the set of the geologic structure determine the long-term adjustment of the riverine-riparian system, but here we are concerned with the historic changes.

The literature is full of classic fluvial geomorphology studies related to sediment types and dominant discharges that controlled channel morphology (Wolman and Miller 1960). Few studies have emphasized the role of vegetation, and seldom the effect of a heavy animal trampling on streambanks. Understanding how loss of vegetation and trampling will effect stream dynamics is where the solution is found to management problems.

Within a given drainage, most of the overall channel length consists of low-order, small streams. Historically, land-use policies and management have not adequately considered these streams and their riparian habitats in livestock management. Their value for fisheries and wildlife both on site and especially downstream is just coming into the limelight. Because the problems of managing small streams are diverse and highly variable, simplistic or "standard" solutions should not be expected . Channel changes are a natural part of equilibrium-stream dynamics. Because natural channels scour and fill, aggrade and degrade, bank cut and deposit, both the immediate and long-term effects of management must be considered.[1]

Any attempt to characterize channel morphology must recognize its three-dimensional aspects. One stream of uniform depth and width may have insignificant amounts of fish-rearing habitat. Another of the same average width and depth, but formed so shallow riffle sections are interspersed with deep pools and overhanging banks, will have abundant rearing habitat and good fish populations. If a stream is undergoing widening it may be responding to trampling by livestock, reduction of streamside vegetation, increases in flow, or increases in sediment.

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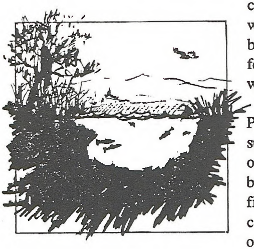
[1] Part of the material in this discussion was taken from Beschta and Platts (1986).

Pools

Pools result from localized scour during moderate to high flows. The fact that a pool has formed indicates that the location is one of intense turbulence and energy dissipation during high flows. As fisheries biologists doing our summer work we usually get the idea that these are the gentle areas that fish like to be in because of the low velocities and higher depths. At certain flow stages pools can be very inhospitable places for fish to be.

The size, frequency, distribution, and quality of pools depends upon the mechanisms of formation and other characteristics such as size of channel substrates, erodibility of streambanks, bedrock control, depth of flow, and amount of large organic debris.

Bisson, et al. (1982) have developed a more detailed classification which recognizes pools based on causative factors: secondary types of pools that remain along flood plains when high waters recede; backwater pools found along channel margins behind large obstructions; lateral scour pools caused by the lateral deflection of water at stream bends or by large obstructions; plunge pools that result when the main flow passes over a complete channel obstruction and drops vertically onto the downstream channel bed; trench pools which occupy long slots in a stable channel bottom; and dammed pools formed by the impounding of water upstream from full or partial channel blockage such as beaver dams. Platts et al. (1986) has developed a rating system for evaluating the quality of each one of these types of pools which is discussed in the section on Inventory and Monitoring.



Pools are the major stream habitat of most fish during winter and summer. Deep, slow-moving pools with lots of instream and overhead cover usually support the highest amount of summer biomass. High quality pools alone, however, do not make the fishery. If this were true we would all be fishing in irrigation canals. Pools of all shapes, sizes, and quality are needed. Young-of-the-year fish need shallow, low-quality pools that other fish will not use. Increased growth allows them to eventually compete, without undue predation, in the higher quality pools. These areas have better drifting food supplies and winter rearing habitat.

Fish typically use a combination of pools for year-around rearing. Summer rearing pools may be reactively shallow and close to riffles and associated with streambanks. In pools, fish may reside near relatively high-velocity water to have better access to passing food. But location, quality, and dimensions can change rapidly during high flow. The quality of a pool depends a lot on how the channel is formed 100 yards above the pool, as this is where the food supply must come from.

A deep, high-quality pool in summer can become a raging torrent during high flows or floods. When conditions are turbulent, fish need to find protection along or even on top of flooded streambanks. They also find protection behind major obstructions, in flooded side terraces, or in less turbulent tributary streams. One of the major needs of fish is high diversity in their complete rearing area, and this is why we should strive for diversity in our management.

Riffles

Riffles, seen during periods of low flow, when substantial portions of the channel bed may become exposed or have relatively shallow water flowing over it, are remnant channel features. They are formed at higher flows and are major storage locations of material. In a meandering stream, riffles are usually located between successive pools at the inflection point of the thalweg. Their form represents a balance between the frequency and magnitude of flows, sediment transport, and other channel characteristics such as obstructions, bank erosion, or deposition. Riffles are the most productive portion of the channel for generating food, especially benthic insects. Good condition riffles afford the needed water velocities to keep the substrate clean, high surface oxygen, and sufficient subsurface flows to remove embryo and alevin wastes. As a result salmonids have evolved a spawning process that meshes well with the hydraulic conditions associated with riffles.

Stream dwelling trout select riffles for spawning which are typically devoid of boulders (because fish cannot move them), low in fine sediments (because of the need for subsurface flow permeability), and high in gravel and small rubble. (This forms a protective roof over the embryos which still allows subsurface flows but which can withstand most of the erosional velocities associated with the stream.) A confounding and very important factor is that trout must select spawning areas that also have high-quality rearing areas nearby. Thus, they may have to forego some of the best spawning riffles within a drainage in favor of lower quality riffles in headwater areas where the young have a better chance for survival.

Bed Material

The surface sediments of gravel channels usually consist of a relatively coarse "armor layer" overlying a mixture of fine- and coarse-grained sediments. These interstices represent ideal habitat for many aquatic organisms, such as over-wintering young-of-the-year fish. Thus, when fine sediments (< 2mm) fill the gravels and influence the amount of voids present, biological reactions occur which are almost always unfavorable.

An increased deposition of fines between gravel and small rubble particles composing the streambed may also affect subsequent bedload transport. Addition of fine sediments filling gravel interstices can prevent the movement of larger gravel particles, thus delaying the onset of bedload transport during large flows. Without some movement, the "cleansing" of fines from the coarser bed sediments during scour, transport, and deposition associated with high flows cannot proceed (Beschta and Jackson 1979).

Trout have evolved and adapted to the natural size distribution of channel sediments (Platts 1979). Trout utilize these substrates as important locations for food and cover. Probably no single particle-size group (i.e., boulder, rubble, gravel, or fine sediment) will create the ideal environment for all phases of salmonid growth and survival. More likely, a complex mixture of sediment sizes, in combination with certain hydraulic conditions, is needed. The optimum spawning substrate mix appears to be gravel containing small amounts of fine sediments. Small rubble is needed to support egg pockets and guard against bed erosion from floods. However, the ability of salmonids to cope with sudden increases in channel sedimentation during certain periods of their life cycle may not be very good.

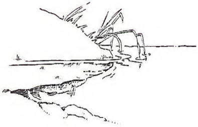
Streambanks

Streambanks bordering small streams (Rosgen's stream order less than 6) provide the habitat edge needed to maintain high fish densities. Fish adapt to this habitat edge because stable, well-vegetated streambanks provide cover, control water velocities and temperatures, and supply terrestrial foods. Bank and corresponding channel profile largely determine the amount of water surface exposed to solar radiation.

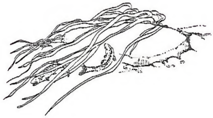
Stable banks are a necessity for fish in small streams. On streams over 30 feet wide vegetative cover provided by grasses and sedges is more important in maintaining streambank stability than in providing cover and shelter for fish. Wider streams require shrubs or trees to effect canopy conditions.

For many streams, vegetation with woody root systems (in combination with grasses, forbs, and other types of vegetation) provides a physical barrier to the effects of high velocities and turbulence, and creates banks with considerable surface roughness and relative stability. The result is that channel widening and erosion at bends can be either greatly slowed or curtailed.

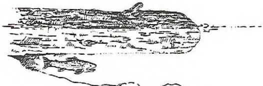
Vegetation on Nevada streambanks, with other characteristics such as soil particle size controls local streambank morphology. Sod-forming grasses can adequately protect the banks of low-gradient streams or ephemeral channels. But, for larger high gradient streams, this type of vegetation alone is inadequate to resist the erosional forces of flowing water. The fibrous root systems of grass vegetation, once exposed to running water, can easily be washed clean of soil particles, leading to rapid bank erosion.



There are two major aspects of bank erosion to evaluate -- lateral movement and the shape the streambank takes as it makes this lateral movement.



Depending on species longevity, an individual plant, such as a tree, may influence the characteristics of a streambank for decades and even centuries. As these individual trees or shrubs die out they are replaced by others in succession, and with proper management, the effects can be perpetually maintained.



Detrimental changes in the productivity and composition of riparian vegetation controlling streambank form can increase stream channel width, decrease stream depth, increase stream temperature in summer and decrease it in winter, and decrease fish food supplies. The undercut streambanks and controlled erosion of well-vegetated banks are much more productive than "laid back" streambanks that are difficult to stabilize with vegetation.

Woody-plant root systems bind and hold soil in place and add large organic debris. This helps form the stair-stepped gradients in small streams so necessary for dissipating stream energy and providing slow-velocity areas needed by fish. Once trees or shrubs are established, other plants fill in underneath. During floods, high stream velocities force resilient streambank vegetation (i.e., willow, alder, grasses) into mats that effectively protect the bank. These mats reduce stream velocities near the bank-water interface, permitting sediments to settle out and build bank form. Accelerated sediment from upland areas is not necessary nor desirable to produce the sediment necessary for the bank rebuilding and maintenance. Natural erosion rates alone will maintain and build streambanks. During channel overflow, floodplains and point bars build through the accretion of trapped sediment. Vegetation also contributes to fish productivity through input of organic material and nutrients, which are then utilized by stream biota.

Ultimately, if revegetation of a formerly unstable channel is successful, the channel will narrow and deepen as sediment is deposited and held by the riparian vegetation. Where such changes in channel dimensions have occurred, channels which were formerly dry during summer may now run water. An aggrading stream channel with corresponding maintenance of side terraces and flood plains, results in a higher water table. This can create additional stored water for release during later periods of the summer.

Vegetation enhances water column and riparian values by cooling streams in summer and keeping them warm in winter, thus eliminating or decreasing anchor ice buildup. Vegetation contributes to streambank strength by shielding the banks from erosion, repairing annual damage through sediment deposition, and binding the soil with roots. Streams thickly covered with vegetation are narrower and deeper than the same type of stream thinly covered with vegetation. Through vegetation growth and fall down comes the large organic debris received by the stream.

The type and condition of the streambank determine how the stream channel responds to flow conditions. Climate, geology, vegetation, and land and water uses all influence streams and their streambanks. Understanding the relationship between the geometry of natural streambanks and watershed dynamics is a relatively new science.

To understand streambank function, one must first understand the fluvial processes that determine channel and bank form. The stability of a bank depends on a balance of disturbing and resisting forces. The bank material, vegetative cover, and channel hydrology primarily control these forces. The physical processes of erosion attract much attention (Wolman 1959, Knighton 1973, Hooke 1979) but the bank forming processes are equally important. These processes involve the magnitude and variability of the flow discharge, and the availability and type of the sediment material to be transported. While each process must be examined separately, a basin-level integration is necessary to fully understand bank erosion and building processes. The ultimate goal is to understand how these processes respond to alteration in land and water uses.

Channel form reflects a stream's spatial and temporal histories, such as high magnitude floods, fire, beaver activity, and livestock grazing. Disturbances to streambanks range from long-term events such as glaciation or large scale vegetative conversions, to short-term events such as a recent storm, or grazing.

Although streambank dynamics are complex and causal agents are sometimes difficult to clearly identify, monitoring streambanks to detect changes is not difficult. Monitoring programs should be designed to track particular processes.

Bank Building Processes

Banks erode and banks aggrade. In a natural stream at equilibrium, over time, every bank that erodes or sloughs off is balanced by another bank being built. During infrequent, large climatic events, much more erosion can take place than building (deposition). During more moderate, frequent events, however, the bank building process catches up. Over time and distance, erosional and depositional forces will balance out as the slope, velocity, area, roughness and pattern adjust to the water and sediment load the channel conducts.

Although the erosional-depositional processes are influenced by many factors, topography is a major one. The steeper the valley slope, the greater the sheer stress per unit of flow. Change in topography or stream slope is usually a long-term adjustment, but when it happens an immense quantity of bank and channel material must be redistributed. Sometimes it can take years or centuries for channels and banks to again stabilize.

Over the short term, different stream reaches respond to the water column energy and sediment conditions in different ways. When the stream energy is insufficient to carry the sediment load, sediment is deposited. Loss of "competence" to carry a sediment load may be from decreased discharge or channel gradient, flow deceleration from obstacles such as trees or other vegetation, or decreased turbulence along the inside of meanders (Morisawa 1968). Bank-building deposition typically occurs along the tip of a meander headland, forming a gravel bar and a narrow trough between the bar and the bank. As the gravel bar grows and vegetation becomes established, suspended sediment deposits in the trough (Morisawa 1968). Deposition continues while sediment is available as the stream flows over the bar and trough. Thereafter, vertical accretion on the abandoned bars, as well as to existing banks and floodplains, occurs from high flow and overbank flow deposits. Newly formed banks are recognized as convex banks. They are often paired with a concave bank leading at the outside of the meander, carved by water flowing with increased velocity and turbulence (Figure I-1).

Overhanging streambank vegetation and roots decelerate streamflow by increasing friction. When the flow loses velocity, the energy to suspend sediment decreases and some sediment settles out, depositing along the existing streambank. As this deposition grows and stabilizes, the channel may narrow. This is an important process in the recovery of severely disturbed streams.

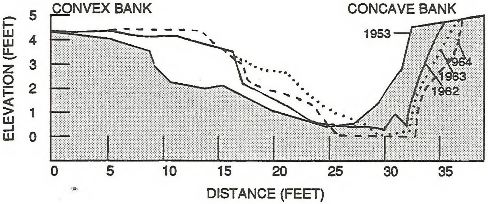


Figure I-1

Bank Stability

Streambank erosion occurs when the sum of the disturbing forces (tractive force of flow, pore pressure, gravity) are greater than the sum of the resistive forces (soil strength, root binding, vegetation mat buffers). Plant roots bind the soil and increase its resistance to gravitational and erosive forces. Erosion of exposed banks (no vegetation) is directly related to stream power and the flow velocity along the sides. Soil bulk density, particle size distribution, cohesive properties, and soil particle shape are thought to affect bank stability (Table I-1).

Table I-1. Properties that influence the stability of streambanks formed by cohesive materials.

a. Vane shear strength
b. Surface roughness
c. Type and amount of clay
d. Soil and surface water temperature
e. Organic matter content of the soil
f. Chemical quality of soils and water
g. Soil plasticity index
h. Permeability of the soils
i. Stream flow forces including turbulence
j. Mean soil particle size
k. Poor water pressure within the soil
l. Bulk density
m. Stream flow regime

Stability Related to Vegetation

Vegetation can control streambank morphology and in turn channel and water column morphology. Streamside vegetation can protect streambanks by reducing the erosive energy of water, and by protecting the streambank from damage by ice flows, debris flows, and animal trampling. Vegetative mats reduce water velocities and erosion potential. During floods, high stream velocities force resilient streambank vegetation (i.e., willow, alder, grasses) into mats that not only protect the bank but trap sediments necessary to maintain and build the bank. Root systems also provide velocity-reducing roughness and anchor the banks by binding the soil. Smith (1976) observed an inverse relationship between erosion and percent of vegetation roots in streambanks. Furthermore, he reported that banks protected by a 5 cm root-mat resisted erosion up to 20,000 times better than bare streambanks. Sod-forming grasses can protect low gradient streambanks while brush, trees, and boulders can armor higher gradient streambanks. Unfortunately, stream scientists have had difficulty modeling vegetative influences and there are no good, easy methodologies at this time.Vegetation is also key to the formation of bank overhangs. When the bare lower bank erodes faster than the upper bank which is bound together with vegetation, an overhang is formed which provides good fish cover. Extensive tree root systems may be undercut considerably before collapsing.

Stability Related to Soil and Water

Relatively stable streambanks are also found where the banks are armored with clay, rubble, boulders, collapsed overhangs, or large organic debris; or where protected from the direct force of the stream's energy by gravel bars or large organic debris which diverts the flow.

Instability

If the sediment supply is less that the local sediment transport rate, and streambanks are not armored sufficiently, sediment erodes from the banks and stream width increases. Stable channels have balanced their size and shape to the volume and energy of flow they conduct. When land uses increase the peak flow, the channel will enlarge to accommodate the increased volume by either deepening or widening. Bank failure can also occur when the soil water reduces the cohesion of the bank soils.

Composite Bank Instability

Some streambanks are inherently less stable than others. Finer textured soils have more cohesion than coarse materials and generally resist erosion better. Composite streambanks with non-cohesive sand and gravel overlain by cohesive sandy silt/clay are common because of the depositional, bank-building processes. Erosion of the lower bank by the streamflow creates an overhang. Shear, beam, and tensile failure eventually collapse the overhangs, even when they are bound by sod. They then slump into the channel along the toe of the bank. The stream must remove the material from these failures before the streamflow can access the lower bank to begin the erosion cycle again (Thorne and Tovey 1981).

While erosion by the tractive force of the streamflow is a major source of streambank erosion, failure also occurs from internal weakening. Frost heaving and wetting-drying weaken soil strength (Wolman 1959) enabling surface erosion as well as tensile (or slab) failure. High soil water content weakens soil shear strength and may create high enough soil pore pressure to push out soil particles (Branford and Piest 1977, Thorne 1982). This occurs in fine textured soils that are saturated by groundwater or are wetted by high streamflow. These banks are left saturated when the stream rapidly retreats. One important implication is that bank stability is not a static property, but can change with seasons and soil water conditions.

Gully Banks

Gullies are formed by severe channel down-cutting in response to high runoff events, loss of streamside vegetation, and advancing valley scarps (Harvey et al. 1985). When stream power creates a sediment transport capability which exceeds the sediment supply, the streamflow may degrade the channel for sediment, resulting in gully-type banks. Gulling may move through a drainage network (continuous) or remain isolated (discontinuous). In an incised channel, the streambanks receive the main force of the stream's energy because the flows no longer top the bank and dissipate in the flood plain. Mass failure of the gully banks is then required for channel widening. When a gully wall slumps to a more stable angle, the sheared soil mass is removed by water. When the toe is removed, the exposed wall is over-steepened and will again fail. Removal of the failed material is a key component of gully wall instability. Gully banks are eroded by three main forces: (1) the weight of the bank mass; (2) added weight of the water mass added to the soils; and (3) seepage and shear stress applied by surface flows. Gully banks fail by arc toe failure, slab failure and "pop out" failure. Other factors include soil water content, electrolyte concentration of the soil solution, freeze-thaw, and wetting-drying cycles (Branford et al. 1973). To eliminate gullies, the channel must either aggrade until flows can top the banks and dissipate energy on the old floodplain, or create a new floodplain within the gully walls. Gully walls stabilize when the gully finally widens enough that the stream does not reach the toe of the walls to remove the slumping bank material.

Livestock-Related Instability

Livestock cause instability in streambanks by trampling the banks, and by altering, reducing, or eliminating bank vegetation (Kauffman and Krueger 1984; Platts and Nelson 1985). Heavy trampling can compact floodplain soils reducing the infiltration of overbank flows. Reduced infiltration and increased runoff further reduce availability of water to grasses and forbs whose roots do not reach the saturated zone. This may decrease the recharge of the saturated zone. This same process on the watershed increases peak flows putting more stress on streambanks (Skovlin 1984). As the channel banks adjust to trampling and vegetation alterations, the position and morphology of the banks change.

Grazing strategies that provide late summer or fall grazing such as season-long continuous, can reduce the cushioning effect of streambank cover, opening the bank directly to ice or high water flows. The condition of the vegetative mat going into fall, winter, and spring greatly influences the stability of the streambank during spring thaw. The stability of concave banks is closely linked to the vegetative potential.

When animals graze directly on streambanks, mass erosion from trampling, hoof slide, and streambank collapse causes streambank soils to move directly into the stream.

Bank Morphology

Streambank form is a response to the bank boundary roughness and resistance of surface soils to flow. In general, the more resistent the bank is to scour, the narrower and deeper the stream tends to be (Beschta and Platts 1986). Increased roughness from vegetation or debris reduces velocity, catches sediment and allows depositional features to form. Streambank form adjusts to changes in flow volume, sediment load, roughness and mass erosion. Climatic variability and geologic structure contribute to bank form, but because they usually operate over large timescales, they will not be discussed here. Local control of streambanks from tree fall, bedrock outcrops, beaver ponds, and livestock grazing often moderates off-site control such as high peak flows. Location also has influence. For example, bank form in headwater streams appears to be relatively more responsive to local controls in the lower reaches (Hickin 1984). Lower river systems may be more controlled by offsite factors such as peak flows. Consequently, mountain-type stream banks tend to be highly variable over short distances and responsive to sudden changes in processes which alter local controls.

The combination of erosion differential--one part of the bank eroding more rapidly than another part--and erosion-deposition can give the streambank a very complex profile. In areas of low fluvial activity, collapsed overhangs or other erosion residue will collect at the toe of the bank resulting in a low bank angle. The angle of the bank above the toe depends on how cohesive the material is and whether it's been subjected to frost heave, wetting or trampling, and may be nearly vertical. Because the upper bank is often composed of more cohesive material and is less often affected by fluvial erosion, it is prone to failure along discrete surfaces within the bank, producing more vertical exposures (Thorne and Tovey 1981). If vegetation binds the upper layer, there may be an overhang (Figure I-2).

Bed and bank material is an important determinant of the shape of alluvial channels and bank stability. Schumm (1960) found a linear relationship between the percent of silt and clay particles in the channel perimeter and the width-depth ratio of stable channels. Over a wide range of discharge and sediment types, stable channels were wide and shallow through coarse alluvium and relatively narrow and deep through finer, cohesive material. This is because cohesive streambanks are better able to resist the tractive force of streamflow than coarse sand or gravel.

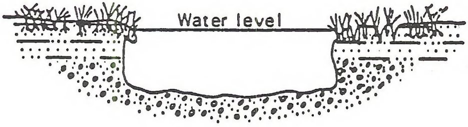


Figure I-2

Vegetative Control of Bank Form

Vegetation buffers the streambank against the flowing water. This buffering may control channel geometry by reducing scour, increasing deposition, and decreasing the rate of concave bank retreat (Hickin 1984). For example, small streams flowing through sod tend to have deeper, narrower banks for the same flows than streams flowing through forested reaches (Zimmerman et al. 1967, Maddock 1972).

Logs which fall across channel can dissipate flow energy, maintain channel stability, decrease bedload movement, and increase water quality (Heede 1985). A number of studies of the effect of tamarisk on Southwest rivers document that the proliferation of this species caused a narrowing of channels. This occurred because the plant trapped and stabilized sediment (Hadley 1961, Burkham 1976, Graf 1978). Furthermore, these studies show that the vegetation increased channel roughness and overbank flood events, which are important for watering floodplain vegetation and raising that saturated zone.

Schumm and Lichty (1963) found that vegetation responses to climatic changes controlled the Cimarron River behavior. They reported a period of channel widening initiated by a major flood, ending a long period of deficient precipitation. Increased precipitation eventually allowed vegetation to re-establish in the wide sandy channel, and that vegetation, in turn, aided deposition and floodplain formation. Sandy channels apparently respond to degrading condition by widening (low bank cohesion) and aggrading condition by narrowing. Experience and logic would modify their conclusion to state that aggradation will occur along the banks if vegetation decreases water velocity there. Otherwise, it will occur along the channel bed, which has more surface area than the banks, perhaps causing braiding. Control is still important but less so than for small streams.

When bank vegetation is removed and plant roots do not help bind the soil, tension cracks can develop and lead to bank failure. Beschta (1983) studied aggradation in the upper Kowai basin in New Zealand and found a 150-year storm event drove streambanks apart, thus widening the channel. Platts and Nelson (1985) found that bank morphology changed dramatically on a site in Big Creek, Utah that had been released from grazing. Extent of undercut bank increased, bank angles decreased, and banks moved closer together. Clifton (1987) reported the same response along a section of Wickiup Creek, Oregon after release from grazing. She also found a 94 percent reduction in channel cross section area (banks moved closer to each other) in a reach that had been released from grazing for 53 years.

Streamflows

Sustainable flows in streams are largely due to watershed discharge as baseflow in shallow and deep aquifers. This baseflow determines if the stream is going to be ephemeral, intermittent, or perennial. Because Nevada streams usually suffer low flow conditions during late summer and fall, baseflow augmentation from side valley storage is very important. To assure that streams remain effluent throughout the entire year, the valley aquifers must not only be recharged each year, but they must be in condition to first hold and store this water for later controlled release. A lot of this potential depends on the quality of the streamside management.

RIPARIAN VEGETATION PROTECTS THE STREAMBANKS FROM EROSION BY WATER, ICE, AND WIND

Streamside managers must first make sure the aquifer remains in place and occupies a position above the stream. Vegetation must occur on the aquifer to facilitate the transfer of water from the atmosphere into the ground and play its part in the development and maintenance of the aquifer. That is, the vegetation must catch the necessary soils and organic material to keep the depth and composition of the aquifer compatible to the absorption and release of water. It all boils down to how much soil there is to store water and how well this soil can hold it.

Vegetation can build these streamside aquifers leading to saturated groundwater flow and increase the levels of bordering water tables so the water storage acts like a reservoir.

RIPARIAN FUNCTION AND STRUCTURE

Riparian zones are disturbance-driven systems that are continually reshaped over time. Riparian systems are dynamic and subject to disturbance at any given time. They are constantly maintained and re-shaped by geomorphic and hydrologic processes such as flooding, deposition, erosion, droughts, and land uses such as livestock grazing.

In healthy riparian systems, water is purified through filtration as it moves through the vegetation, removing sediment. The system acts like a sponge, retaining water in streambanks and surrounding ground water aquifers. Riparian vegetation in healthy condition can absorb and dissipate the energy of flood waters before they reach high value fisheries or wildlife resources. Healthy riparian systems have been shown to improve baseflows, reduce ice buildups, and filter sediments both by direct trapping and stoppage of ice-containing sediments.

SOLAR RADIATION ACCOUNTS FOR ABOUT 95 PERCENT OF THE HEAT INPUT DURING MIDDAY PERIODS IN MID-SUMMER

The major role in alluvial land types of the riparian zone is to function as a floodplain and dissipate stream energies associated with high flows. This, in turn, permits sediments to deposit and continue development of the alluvial valley floor. The valley maintenance processes cannot be maintained unless the riparian area is in a supportive condition. As we broaden our understanding of riparian systems we will not concentrate on filtering effects and nutrient sinks, or keeping streambanks stable. We will be working riparian needs into the needs of the valley as this land type plays the greatest role in productivity of the stream over the long term.

Riparian systems bordering streams depend on the kinetic energy of flowing water to erode, transport, and deposit materials needed for their maintenance. In turn this riparian habitat is critical to the functioning of the stream as quality habitat. Riparian systems are highly connected to other systems (stream and uplands). This can be beneficial or detrimental depending on the stresses or benefits applied to the riparian habitat from the surrounding systems.

Temperature Influences

Stream canopy cover regulates sunlight reaching the stream surface and contributes organic energy. Summer stream temperature of western streams has increased over the past century as this vegetation has been reduced or species composition has changed. Streams with little or no vegetative canopy are very susceptible to the formation of anchor ice and in turn to channel, vegetation, and bank erosion when this anchor ice is moved by flowing water. The amount of vegetation influence is determined by both the size and density of the vegetation and the size of the water column. In first and second order streams grasses can have temperature control effects but in stream order 3 to 5 grasses have little effect and brush is required. For vegetation to have much control over 6 and 7 order streams, tree borders are required.

Bank Stability

Generally, plants with strong root systems are required to hold streams and riparian zones together. Willow, sedges, and rushes fit this requirement very well. Their stems provide roughness and resistance to flow and at high flows bend to trap transported sediment. These mats reduce the water velocity along the streambank face causing sediments to settle out and become part of the bank. Sedges with willow overstory in small streams create the most optimal streambank structure. When sedge communities revert to less favorable communities like Kentucky bluegrass, streambanks get in real trouble. Also, vegetative matter that can be returned to the soil is badly needed. This increases the moisture-holding capacity of the soil as organic matter can hold nine times its own weight in water. To graze all the streambank vegetation off each year robs the soils of some badly needed binding material plus nutrients.

The binding effect of the roots helps maintain the positive factors of the bank-building processes. A diversity of plant species that can both bind soils in place and trap soils that are moving is the best mix.

Floodplains

Flooding is one of the most important valley forming processes for maintaining fisheries habitat. Overbank flooding is critical for the exchange of nutrients, organic energy, and sediments for floodplain maintenance and building. Many flood plains have to be flooded periodically to deposit seeds and for the subsequent development of seedlings into mature brush and trees.
Flooding greatly influences water tables which influence the health of riparian vegetation. Where baseflow of streams is dependent on groundwater storage, it may be advantageous to maximize groundwater recharge through overbank flooding.
Flood plain building is in turn influenced by the vegetation's ability to trap, store, and use sediments. Flood plains that have their vegetation reduced or eliminated generally erode down to the level of coarser materials and even to bedrock. Healthy riparian flood plains slow the flow of water and allow it to spread and soak into the flood plain like a sponge, which in turn raises water tables. When flood plains rebuild through accretion of sediments, they increase the area for water absorption and storage and improve recharge of aquifers by allowing gravity to work on the stored waters.

LEGAL MANDATES

INTRODUCTION

To work effectively with your colleagues and managers in federal or even state agencies, you must understand the laws, regulations, and legal guides they are obligated to work under. Appendix "K" lists the federal laws and acts that are significant in protecting and enhancing riverine-riparian habitats. Only a few of the more important ones are discussed to provide a quick reference to what land managers must observe. Information on the other laws and regulations listed are available at the respective agencies or your state law library.

An attorney should always be consulted when you enter into any project that may have legal ramifications. The interpretation of laws and regulations is far above our capabilities, and that is why attorneys exist. Use them; they can be your best ally and keep you out of areas where you do not belong. Also, attorneys can be creative, not just restrictive. Attorneys can find ways to get things done that managers never thought possible. Many managers will constantly list legal reasons why projects or changes cannot occur, when actually these reasons do not even exist. Consult with attorneys not only to avoid trouble, but also to assist in finding ways to accomplish useful ends.

TAYLOR GRAZING ACT

Any one working with grazing issues must understand what lead to the passage of the Taylor Grazing Act and why the Act failed to bring about the needed range improvement in riparian areas. A knowledge of its history can be valuable in gaining an understanding of the position we are in today. The historic facts display the political reality that is still with us today.

Until the Taylor Grazing Act came along the public rangelands were an unregulated mess. The Taylor Grazing Act (1934) gave the Department of Interior Grazing Service, which was later to become the BLM, a mandate to manage its federal lands which was similar to some of the same mandates the Forest Service had already received.

The Act's main purpose was to stop the serious injury occurring to the public's land caused by the improper management of livestock. A major purpose was to stop physical competition for range forage. Since there was no legal system for carving up the range, ranchers literally "fought it out" over control of acreages. By 1934 this was unacceptable behavior, even by western standards. Also, the damage done by unregulated use was astonishing.

On June 7, 1933 Interior Secretary Harold Ickes wrote in his diary, "The public range is being overgrazed to an alarming extent. Part of it has already been destroyed and there will be more of this until there is some control." The day President Roosevelt signed the Act into law, Ickes wrote, "It has been a long, hard fight to get this bill passed." (The Department of Agriculture vehemently opposed the Act). The Act took away from the Department of Agriculture, which was doing a miserable job of range stewardship, and gave to the Department of Interior the powers to begin preserving and redeeming the range which was so rapidly being destroyed.

In reality, the most significant thing the Act did was to hand the range over in its entirety to established ranchers. Those ranchers who were smart enough to have homesteaded the valley bottoms got the range. The itinerant drifting cowmen were driven out by homesteaders who were despised by many big cow operations because they were fence builders. It is extraordinarily ironic that the very people who were foresighted enough to fence the lands never had the intelligence to avoid destroying the lands.

The Act would later give the BLM broad discretion in creating grazing districts and grazing boards, in establishing rules and regulations, in making cooperative agreements with ranchers, and in taking any management action needed to accomplish the purposes of the Act. The Act required the grazing advisory boards to be made up of "affected" grazing ranchers only. This killed any chance for the incoming BLM to move in the direction of multiple use, as the Forest Service was doing. Ranchers continued to make all the decisions as to how the ranges were to be managed. The Act, therefore, had little effect in getting the BLM to move towards better riparian-stream management. The BLM had to make broad concessions to ranchers to gain support for their program under this Act.

The Act resulted in giving grazing preference usually to ranchers who were near-by land owners. These owners had water rights that controlled livestock use on the adjacent valley bottoms. The Act gave the permit ranchers security of tenure on the allotment. This created paper property useful for going to the bank for loans or to sell as a property right to the next buyer. While the Act did state that the issuing of a permit did not give the permittee any right, title, interest, or estate in or on the public lands, this was not in line with how things operate in the real world. The Act was clearly oriented toward production of forage for use by ranchers. Wildlife and fisheries received little, if any, attention.

In 1935 grazing advisory boards were established and filled with livestock operators in an effort to gain support from the ranching industry. The boards quickly became more than advisory bodies by determining grazing capacities, setting stocking levels, ruling on license applications, arbitrating disputes, and helping to determine season of grazing use. Ranchers quickly dominated the BLM.

Management of the BLM continued under the guidance of the Taylor Grazing Act into the 1960's when Congress enacted the Classification and Multiple Use Act of 1964. The 1964 Act gave the BLM temporary multiple use management authority which expired in 1970. Riverine-riparian habitats had fared miserably under Taylor Grazing Act guidance. For many years habitats would do no better under the acts that followed which were supposed to improve BLM management. Still today, the old Taylor Grazing Act forms much of the guidance for livestock grazing on public lands. The act seems almost immune from losing its influence even though it has been totally ineffective in eliminating damage to riverine-riparian habitats. Braun (1986) concluded from an extensive analysis of the Taylor Grazing Act, Federal Land Policy and Management Act, the Public Rangelands Improvement Act, and the BLM'S policy that there are no statutes that reveal any enforceable mandate for riparian zone and fisheries rehabilitation on BLM lands. This is pretty scary, but we need to use whatever is available and make the most of it. There is still a need for additional mandates from Congress.

In summary, the Taylor Grazing Act failed miserably. It continues to fail today and it is still on the books.

MULTIPLE USE ACT

In 1897 under the Organic Administration Act, the Forest Service received its just mandate to manage streams. The Act's specified purpose was to secure favorable conditions of water flows. This was largely ignored until the Multiple Use Act.

The Multiple Use Act of 1960 established watershed protection in the form of protecting water quantity, preserving water quality, and avoidance of flooding. The intent of the Act was a far cry from the management in the 1950's that called for converting range lands to private ownership.

Congress passed the Multiple Use-Sustained Yield Act (1960) which by specifically listing the multiple uses (except mining), supported a balanced land use management with stricter conservation requirements. The Act specifically named wildlife and fish needs for management direction. Thus, the Forest Service is charged with protecting and enhancing wildlife and fisheries habitat as related to food, cover, and water.

At this point we need to put the Multiple Use Act in perspective. A good way to do it is to look at some historic accounts. If you wonder why the Act says "Wildlife and Fish" instead of the other way around, which is the more common way to say it -- it's because the Forest Service did not want fish to be first in the alphabetical list of the multiple uses. Ed Crafts, who was Assistant Chief of the Forest Service during drafting of the Act, stated in American Forests:

> *"The only reason we chose "Wildlife and Fish" (over 'Fish and Wildlife' was to make that resource group come last in the listing of multiple uses. Fish and wildlife are under control of the States on National Forest Lands. This would have made those resources come first and we didn't want fish to be listed first in an enumeration of national-forest resources."*

Multiple use means "the greatest good for the greatest number." Management and utilization of all the various renewable surface resources will be done in a manner that will best meet the needs of the American people. Considerations will be given to the relative values of the various resources, not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output. A key part of the Act is that it clearly states that one resource will not be used to the detriment of another resource -- a key fact to constantly apply in your fishery-wildlife management.

Sustained yield of the several products and services mentioned in the Act means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the land without impairment of the productivity of the land.

With the Multiple Use Act now in effect for 30 years, it has been plainly demonstrated that it's influence on riverine-riparian management is not productive. The Forest Service used the Act to move away from its practice of applying proper stocking rates through reductions to cooperating with permittees and adding range improvements to justify maintaining and increasing livestock numbers. The approach made sense but the expertise was not sufficient to put proper range improvements or management on the ground, and the riverine-riparian habitat continued to degrade.

The Act did give federal land managers authority to change land use priorities if the political context allowed. Thus, a bold manager had unassailable authority to prohibit livestock from grazing improperly in riparian zones. Unfortunately, that authority was seldom used, and today is still not being used sufficiently. Thus the need for additional National Forest Management Acts that would give the Forest Service added mandates and needed direction to move towards balanced resource management.

WATER QUALITY ACT

There have been a series of water quality acts and regulations attempting to bring the Nation's waters back to productivity. In 1972 Congress passed the Federal Water Pollution Control Act (FWPCA), which was later changed to the Clean Water Act (CWA). The purpose of this Act was to systematically eliminate the discharge of pollutants into the Nation's waters, mainly from point sources. This Act had great effect on the needed improvement of the Nation's waters except when the pollutant was generated from a non-point source.

Under the 1972 mandates, and in the absence of uniform regulatory control over non-point pollution sources, little progress was made towards regulating pollution from livestock sources. EPA has taken the position that it is the states' and local governments' responsibility to control non-point source pollution. The states until recently have regulated mainly point source pollution because that was where all the money was.

The FWPCA waives the federal land manager's sovereign immunity from state water quality standards and therefore their activities as related to water quality come under state laws and regulations.

In response to the magnitude of public concern about nonpoint source pollution, Congress included new sections (303 and 319) in the 1987 Amendments to the Clean Water Act. Section 303 requires each state to adopt water quality standards for its waters. Section 319 ("Management of Non-point Sources of Pollution") provides guidance and authorizes some financial support, for the eventual establishment of a state non-point source management program. Each state has supposedly completed it's assessment of non-point sources of pollution which requires a process to identify BMP's (best management practices). Lack of personnel, expertise, and money has been a major obstacle in keeping the states from fulfilling their obligations under this Act.

The latest 1987 Water Quality Act stresses three approaches to solving non-point pollution problems. They are Assessment, Targeting, and Management/Implementation. These approaches will allow state water quality managers to identify livestock pollution problems and take necessary corrective action to the extent feasible.

In simplification, the Water Quality Act mandates that (1) existing water quality necessary to support existing or designated uses may not be degraded; (2) that designated, but unachieved uses of water may not be redesignated unless the state finds them unattainable, and (3) where water quality exceeds that necessary to support propagation of fish and wildlife, that quality must be maintained. This gives you some powerful mandates to ensure that riverine-riparian habitats are managed properly.

The Water Quality Acts are the best mechanism available to use in developing the justification for more compatible grazing strategies. The acts substantially constrain land managers' wide discretion that allowed them for so many years to ignore riverine-riparian habitats (Braun 1986). One of the major problems still existing, is that the federal agencies are so tied up in their own laws and regulations, they tend to ignore that the water quality acts even exist. The water quality acts must be brought home and implemented for better riverine-riparian management.

The responsibility of the Forest Service to protect water quality and fisheries is addressed by the National Environmental Policy Act (1969), Section 311 of the Clean Water Act (1972), the National Forest Management Act (1976), Executive Order 12088 (1981), other directives, memos of understanding, and agreements. The Forest Service has attempted to take the position that if they apply a BMP this removes their responsibility for complying with state water quality standards. This issue has been partially settled by the Ninth Circuit Court of Appeals in the Northwest Indian Cemetery Protective Association v. Peterson (Chief, Forest Service). In this case, the Ninth Circuit Court of Appeals upheld a lower court decision mandating that the Forest Service abide by the state water quality standards. BMP's by themselves would not suffice for compliance. The Court determined that BMP's were merely a means of achieving those ends; they are not themselves legal standards. In answer to this case ruling the Forest Service has agreed in memorandums of understanding that they will provide to the states a general assessment of water quality accomplishments, problems, and priorities in accordance with Section 305 (B) of the Clean Water Act. This will allow the state to better evaluate federal consistency with water quality regulations.

Section 319 mandates to the states do create new opportunities for wildlife and fisheries biologists. Tools are made available to get assessments of those streams and lakes under federal jurisdiction to see if they are abiding by state water quality standards. This Section requires the states to develop BMP's for the federal agencies to abide by.

The Water Quality Act of 1987 and the Water Quality Standards Regulation (1983) provide the legal basis for conducting bio-assessments to evaluate biological integrity. Section 101 states that the objective of the Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Section 303 allows states to adopt criteria based on bio-monitoring and assessment where numerical criteria for toxics are lacking. This gives you the authority to use fish and wildlife health and survival as monitoring tools to determine compliance.

NATIONAL FOREST MANAGEMENT ACT (NFMA)

The NFMA was passed by Congress because the Multiple Use Act of 1960 was just not getting the job done. The Multiple Use Act was still resulting in the domination of single use management. NFMA called for equal consideration of all renewable resources, and in combination with other Acts required the Forest Service to integrate the management of all resources into one consistent Forest Management Plan that included public involvement. NFMA does not in any way govern the way the BLM is to conduct its management programs.

NFMA requires the Forest Service to recognize the fundamental need to protect and improve the quality of water resources, and all National Forest plans must include coordination of watershed, wildlife, and fish with all other uses. The Act re-emphasizes the need for the Forest Service to comply with NEPA. Executive Order 11988 was made to coordinate with NFMA and this Order gave additional direction for managing riparian zones. The Order stated that federal agencies must avoid, to the extent possible, long- and short-term impacts to floodplains (riparian habitats).

FISH AND WILDLIFE MUST BECOME AN INTEGRAL PART OF MANAGEMENT AS DIRECTED BY THE NFMA

- SENATOR HUBERT HUMPHREY

Section 219.27 of the Act requires that riparian areas within 100 feet of perennial streams, lakes and other bodies of water receive special attention. One hundred feet is not enough territory for good riparian management but in the case of livestock grazing if you take care of the first 100 feet on most allotments you are probably taking care of the remainder. Other sections of the Act call for proper vegetation management, maintenance of good watershed conditions, requirements for fish and wildlife management, and needed restoration of grazing lands. This Act by itself could achieve many of your goals in riverine-riparian management but, when combined with the other Acts, especially the water quality acts, the mandates are quite strong on how the public's lands are to be managed.

FEDERAL LAND POLICY AND MANAGEMENT ACT (FLPMA)

The BLM was a politically weak agency that had little organic authority and desperately needed a statute to give the agency some power over its user constituencies such as miners and ranchers.

FLPMA, the BLM's organic act, contains policy directives which the agency must use to guide management actions. One reason FLPMA was passed was because the BLM was not giving resources other than livestock grazing an even break in its land management decisions. FLPMA formalized the shift away from the production orientation of public rangeland management which occurred under the Taylor Grazing Act interpretations, to preservation and conservation of rangeland resources that benefit all users, and especially future generations. FLPMA did not repeal the Taylor Grazing Act, but amended several of it features.

FLPMA is a complex law that among other things repealed all the homesteading laws. The Taylor Grazing Act like the old 1872 Mining Law is still with us. A main purpose of FLPMA was to counteract some aspects of the Taylor Grazing Act. It limited the role of grazing advisory boards and required public participation in the decision making process.

FLPMA, along with the Public Rangelands Improvement Act (PRIA), interjected the concept of multiple use into BLM's land management practices. The problem with multiple use and why multiple use has failed in riparian management is that it allows the agencies to do pretty much what they want to do. Courts have consistently refused to second guess land management decisions challenged for violating the multiple use mandate.

The Act also renounced the land disposal status of the BLM mandating the retention of those lands needed by the public to remain in public ownership. To try and get the public mind off the fact that the BLM was managing public lands, the BLM has made a comprehensive effort to refer to "public lands" as "natural resource lands." The BLM still uses this new terminology in its every day management.

Sections 1711 and 1712 of FLPMA require the BLM to prepare and update land use plans for all of its public lands. In this effort it must observe the principals of Multiple Use Management, use an interdisciplinary approach, give priority to areas of critical environmental concern, and consider all present and potential uses of the public lands. FLMPA charges the BLM to designate and give priority to "Areas of Critical Concern" (ACEC), and it was hoped that historic damage to these areas would cease and be reversed. Unfortunately, FLPMA did not require that historic damage to ACEC's "cease and be reversed." The BLM position appears to be that ACEC's are a preservation tool, not a restoration tool. In other words the BLM will not designate a battered out riparian system as an ACES and then specially manage to restore the system. The ACEC section of FLPMA could provide the BLM with an excellent tool for restoring riparian habitats. Congress probably meant for ACEC's to be used in this manner.

Nowhere in FLPMA is there any mention that local interests are of special significance. Precisely the opposite is true. The Act continually refers to the national interest.

In 1984 the BLM, based on this Act, promulgated rules. One rule established the "Cooperative Management Agreement" (called the Stewardship Program by many) which will be discussed later. This rule again allowed favoring of livestock grazing over the other mandated multiple uses, but the rule was soon contested in court and has been blocked to date.

In summary, FLPMA provides the congressional intent, sufficient delegated authority, and a source of funds for riparian ecosystem restoration projects on the federal lands. If the mandates of FLPMA are not followed and put into effect, riverine-riparian habitats will continue in their degraded state.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA requires the federal government to make full disclosure of the environmental consequences of its actions. The Act sets out procedural requirements that bring environmental considerations into federal decision-making. The Supreme Court has ruled that NEPA places upon an agency the obligation to consider every significant aspect of the environmental impact of a proposed action, and insures that the agency will inform the public that it has indeed considered environmental concerns in its decision-making process.

Unfortunately, NEPA is a vastly overrated law. Forcing an agency to open up its political process and publicly consider alternative management directions doesn't really require it to change the usual way of doing business. Once an agency has jumped through NEPA's procedural hoops, NEPA is not really a barrier to anything. Usually the best it does is delay the project but the agency will simply rewrite the Environmental Impact Statement until they get it right and then go ahead with the project or plan. Still we need to use NEPA for all its values as some efforts have been very rewarding.

NEPA requirements are met by using one of three documents -- Environmental Impact Statements, Environmental Assessments, and Categorical Exclusions. Procedural requirements of NEPA are interdisciplinary input, public scoping of issues, accuracy of data, and notification of interested parties. An Environmental Analysis (EA) is the workhorse Forest Service NEPA document. Depending on the complexity of the project, the EA is approved by the District Ranger or the Forest Supervisor.

In an effort to increase productivity, and in many cases try and slide by without a proper analysis, Categorical Exclusions (CE's) are used. Categorical Exclusions are an effective way to meet NEPA's intent with minimal time and person power. They are generally approved at the district level.

FOREST AND RANGELANDS RENEWABLE RESOURCE PLANNING ACT (RPA)

RPA (1974) is a "top-down" planning law concerned with increased output of traditional public land products. This is different than NFMA which is the "bottom-up" counterpart. NFMA contains the environmental constraints on RPA goal setting.

RPA required the Forest Service to perform periodic assessments of the status of the Nation's renewable natural resources. This required a comprehensive assessment of present and anticipated use, demand for, and supply of renewable natural resources from public and private lands. This was to be accomplished through analysis of environmental and economic impacts, coordination of the multiple uses, managing for sustained yield opportunities, and using public participation in development of the program.

The accompanying Resources Planning Act Assessment of 1975 calls for projecting increased demands on rangelands for the production of domestic livestock through the year 2020. The RPA goal was to increase AUM's of domestic livestock grazing from 237 million to 380 million by the year 2010. The Forest Service has yet to be able to come to grips with the mandates in RPA because of its heavy demands, and there is a lot of "wiggle room" in its use. Also, the definition of an AUM has never been decided properly and allows much more grazing than is presently being planned for. When an AUM was first defined (the definition still used today) it was the amount of forage a cow and a one- or two-month old calf, who was still too young to take much forage could consume in one month. Today, through animal husbandry, calves are now being born as early as November and when the calf goes on the range in the spring it is a heavy forage consumer. This large under-yearling is still not counted as a grazer although it could be consuming more forage than its mother. Therefore, when you hear that livestock grazing forage utilized today is still at the same rate it was many years ago, this is completely erroneous. If the AUM's grazed today are the same as in the past then the amount of forage utilized could have doubled.

PUBLIC RANGELANDS IMPROVEMENT ACT (PRIA)

PRIA is primarily a financing mechanism to channel money into on-the-ground improvements in cooperation with the permittees and in some cases other users. In other respects, however, it re-emphasizes the scientific/planning approach of FLPMA and even more severely castigates the way the lands have been managed by administrators by laying out the poor condition of the Nation's rangelands. PRIA also reaffirmed FLPMA's policy of inventorying the public lands and added a national commitment to manage the public lands so they can become as productive as feasible.

The Act's purpose was to focus on the improvement of rangelands and their associated water sources. The McClure Amendment was designed, however, to buffer the management effects of PRIA by not allowing any livestock reduction to be more than 10 percent in any given year. Also, a provision was included in the bill to set grazing fees legislatively. This clause was designed to continue giving public land grazers low cost forage.

Considered together FLPMA and PRIA provide some authority for the BLM to get on top of its riparian problems. These Acts, however, do not guarantee that this will be done unless the BLM wants it done. Whether the agency does a good job of abiding by these Acts is still at the agencies' discretion.

ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 is of great interest to Nevada because of its large number of classified species such as the desert tortoise and the Lahonton cutthroat trout. The Act essentially declared the government of the United States to be firmly opposed to the extinction of species, both plant and animal. A key provision was that ecosystems upon which endangered and threatened species live must also be preserved, which in turn requires diversity in habitat to meet species requirements. As it has with the spotted owl and will with the desert tortoise , this Act will continue to have great repercussions and result in great changes in how land is managed.

STEWARDSHIP PROGRAMS

The stewardship program was a good idea that got smashed under the Jim Watt tenure. Watt attempted to use the stewardship idea to simply get the BLM out of the land management business. He literally turned the range over to ranchers and then expected the agency to turn their backs on them. In theory the stewardship concept is a good one that can still provide an incentive to livestock managers if properly used.

FLIPMA AND PRIA allowed the BLM to promulgate rules in 1984 which established the "Cooperative Management Agreement" (CMA) program. This program was intended to allow delegation of federal land management responsibilities to ranchers of "proven stewardship." They would then have sole responsibility for managing federal rangelands leased to them for a minimum term of ten years. A CMA recognized the operator as the steward of an allotment. The operator would be given maximum management flexibility. Discretionary objectives such as fish and wildlife habitat improvements could be implemented by him. This CMA program is easily mistaken for the Stewardship Program allowed under PRIA called the "Experimental Stewardship Program." The Experimental Stewardship Program is really an experiment without a control. Little data has been collected to show whether it has succeeded or failed. It was thus doomed to fail. Both programs allowed the livestock industry to take over the management of all uses including wildlife and fisheries habitat.

The Natural Resources Defense Council filed suit challenging the CMA program. Judge Ramirez found favor with the Defense Council's suit and the BLM was enjoined from implementation of the CMA program. Judge Ramirez concluded that the CMA rules constituted an impermissible delegation of regulating authority to a class of individuals Congress sought to regulate.

GRAZING ADVISORY BOARDS

Bureau of Land Management

The National Grazing Advisory Board (referred to as a multiple use board) advises the BLM on items of national interest. District grazing advisory boards advise BLM districts. These report to and advise the District Manager on allotment management plans governing (a) livestock grazing operations and practices, including any inventories and monitoring, and (b) the type, location, ownership, and general specifications for range improvements to be installed and maintained to meet grazing needs. The board also advises the District Manager in allocating those range betterment funds that are to be used for range improvements that meet the needs of livestock grazing on public lands in the district.

The BLM expects these boards to continue, but their continuation is subject to biennial review and renewal as required by Section 14 (a)(2) of the Federal Advisory Committee Act (Public Law 92-463).

The district board is comprised of not less than five nor more than eight elected members. If more than one species of livestock graze within a district resource area, one member is elected for each of the two most common species. Further, one member represents each resource area. The number of members, as well as the resource area and/or species of livestock each member represents, is announced in a call for nominations by the District Manager prior to election. The board is reflects the perspective of people grazing livestock on the public lands. To be eligible to serve, one must hold a lease or permit to graze livestock on public lands within the district.

Members are elected biennially. The District Manager issues a call for nominations for membership, identifies the number of positions to be filled, and the resource area and/or species of livestock each position is to represent. The call goes to those persons holding livestock grazing leases or permits for lands within the district.

All meetings of the board, including field examinations, are open to the general public and news media. Any organization, association, or individual may attend, file a statement with, or appear before the board regarding topics on a meeting agenda. The District Manager can require prior notification by those desiring to attend field examinations and/or be heard by the board, set per-person presentation time limits, and require that presentations be reduced to writing and that copies be filed with the board. Agendas are approved in advance by the District Manager.
The board may invite people to advise it in performing its functions. Minutes of each board meeting, recommendations made, and copies of all studies and reports received, issued, or approved are maintained in the District Office. They are available for public inspection and copying during regular business hours.

U. S. Forest Service

The Forest Service does not rely nearly so heavily on grazing advisory boards as the BLM and in many cases does not use them. The Federal Land Policy and Management Act directed establishment of grazing advisory boards upon petition of a simple majority of term grazing permit holders under the jurisdiction of a National Forest headquarters office, but the Forest Service lost its authority for Grazing Advisory Boards in 1985. It may still maintain de facto boards to advise and counsel forest officers in the development of allotment management plans, and in the planning and spending of range betterment funds. If using a grazing advisory board, the Forest Service will consult with and carefully consider and evaluate board recommendations when there are contemplated changes in policy that would affect the development of allotment management plans or the utilization of range betterment funds.

The Forest Service must also encourage attendance by other interested groups and individuals at board meetings.

FOREST PLANS

The National Forest Management Act called for the Forest Service to complete Management Plans for each National Forest. Forest Service plans establish multiple use goals for desired future conditions, management prescriptions, and standards and guidelines for future decision-making. It is very important for you to be a part of this plan and be the representative for fish and wildlife. Remember that the plans are always adjustable.

Specific project activities such as an allotment management plan must abide by the Forest Plan. AMP's must meet both the letter and intent of the Forest Plan. This will take years of work, especially at today's slow pace of accomplishment, but it's a job that must be done.

The Forest Supervisor may change proposed forest action schedules to reflect annual budgets and funding. These Forest Plan amendments aren't considered *significant* amendments. Significant amendments require the preparation of environmental impact statements because they significantly alter the long-term relationship between levels of multiple-use goods and services projected.

The Forest Supervisor may amend the Forest Plan. Based on an analysis of the objectives, guidelines, and other contents of the Forest Plan, the Forest Supervisor determines whether a proposed amendment would result in a significant change in the plan. If the change is determined to be significant, the Forest Supervisor follows the same procedure as that required for development and approval of a Forest Plan. If the change resulting from the amendment is determined not to be significant for the purposes of the planning process, the Forest Supervisor may implement the amendment following appropriate public notification and satisfactory completion of NEPA procedures.

A Forest Plan shall ordinarily be revised on a ten-year cycle or at least every 15 years. It also may be revised whenever the Forest Supervisor determines that conditions or demands in the area covered by the plan have changed significantly or when changes in RPA policies, goals, or objectives would have a significant effect on forest level programs. In the monitoring and evaluation process, the interdisciplinary team may recommend a revision of the Forest Plan at any time. Revisions are not effective until considered and approved in accordance with the requirements of the development and approval of a Forest Plan. The Forest Supervisor shall review the conditions on the land covered by the plan at least every 5 years to determine whether conditions or demands of the public have changed significantly.

GRAZING STRATEGY DEFINITIONS AND INTERPRETATIONS

INTRODUCTION

A grazing strategy is a specialized plan of grazing management. The plan defines recurring periods of grazing, deferment, nonuse, and rest within an area. Rest usually infers at least a year of nongrazing. Nonuse can be any time period as specified.

The type, class, and phenological timing of grazing is outlined in the grazing strategy. Strategies have been developed for upland ranges to increase plant and litter cover, encourage growth of favorable plants species, improve plant species composition, increase plant vigor, and protect soil from erosion. The strategy also reflects the needs of the livestock operator in so far as possible. These same objectives must be met when using the riverine-riparian area for livestock grazing.

Range Scientists (Holcheck and Gifford 1983) have concluded that it is extremely doubtful that any grazing scheme will improve a local hydrologic circumstance over that found under ungrazed conditions. In an unpublished project, the Pleasant View allotment near Malad, Idaho went from bare ground drainage bottoms to excellent vegetated bottomlands, then again under poor grazing back to bare bottom drainages within a 20 year period (Hugh Harper, personal communication). The Morgan Creek allotment near Challis, under improved management went from poor to good to excellent in 10 years and today is still in good condition (Hugh Harper, personal communication). What Harper is telling us is that changes in grazing strategies can improve riparian systems. What Holcheck and Gifford are telling us, and my experiences tell me is true, is that very seldom under any grazing strategy can you improve riverine-riparian systems beyond what nature could do by herself.

GRAZING STRATEGIES ARE COMBINATIONS OF PERIODS OF USE, REST, AND NONUSE, IN ORDERLY TREATMENTS

Range managers still lack specific knowledge of the conditions under which individual grazing strategies give best results. This observation also applies to the status of fisheries and wildlife research and management. To make matters worse, researchers such as Holcheck (1983) have found little difference in cattle performance between different grazing strategies. It has definitely been demonstrated, however, that riverine-riparian systems degraded from improper grazing, once released from grazing, can rehabilitate to their once healthy condition.

With little clear-cut economic advantage expressed by range scientists, from specialized grazing strategies on upland range sites, there is little incentive for managers and users to change from a poor strategy to a more favorable one. Therefore, economic benefits from grazing strategies designed to improve stream-riparian zones as well as fisheries must be demonstrated. There are grazing strategies that will maintain healthy environments -- these must be put into effect immediately on degraded riparian systems.

PUBLISHED EVIDENCE FAILS TO SHOW THAT ANY UPLAND GRAZING STRATEGY CONSISTENTLY OR SIGNIFICANTLY INCREASES PLANT AND LITTER COVER ON WATERSHEDS

-HOLCHECK AND GIFFORD 1983

Whether grazing strategies favor or depress the production of red meat is an important consideration in designing and implementing them. But of greater importance is whether the grazing strategy is protecting soil, water, vegetation, and all animals dependent on these resources. A healthy riverine-riparian system derives the best mix of products, whether it is on private land or public land. The application of a properly applied grazing Best Management Practice (BMP) may not always be the best multiple use management approach but it is the best use of the resources approach.

This guidance document reviews the ability of current grazing strategies to meet fisheries-wildlife needs. The conclusions are based on the information in the references cited and the author's experience. The evaluations are based on the commonly used stocking rates and grazing intensities used on today's allotments. Obviously, one cow grazing a large allotment at 1% overall utilization under any selected grazing strategy would be compatible with fisheries needs.

This report concentrates on the Great Basin, but will have application in other similar areas. Fishery needs are viewed as the major objective in the evaluation of each livestock grazing strategy. The management goal is assumed to be that any strategy should attain or maintain all the affected range types, especially riparian, in a healthy condition that meets the needs of all the other beneficial uses.

There are two major reasons why grazing strategies in the past have not protected the health of riverine-riparian systems. One is that streamside areas were incorporated into the large pastures and not identified as separate and distinct areas needing specialized management. Consideration of these streamside zones in the development of grazing strategies provides the best opportunity for the development of compatible grazing strategies. The second reason is overstocking as there is not a single strategy that will work if the range is overstocked. This situation completely disrupts the ability of the strategy to control animal distribution.

Platts and Nelson (1985) showed that in 23 of 25 study sites in Idaho, Utah, and Nevada, streamside vegetation use by cattle was twice as heavy as overall pasture use under the commonly used grazing strategies.

A COMPATIBLE GRAZING STRATEGYMUST COMBAT THE EFFECTS OF SELECTIVE GRAZING

Another problem in designing and applying grazing strategies is that the design is in the "eye of the beholder." Range managers tend to base their design on upland vegetation recovery and red meat production. Fishery and wildlife managers base their design on what will produce the highest animal populations. The two must come together and change their goals to building the most healthy riverine-riparian system possible. This will provide the most benefits to the people.

This is not an easy task as land types, vegetation types, amount of rainfall, soil conditions, stream types, vary greatly. Therefore there will not be one grazing strategy that will do all things for all resources over all lands.

Grazing Strategies are often site-specific and therefore cannot be "cookbooked," but must be developed to fit the needs of a specific land area.

CATTLE EXERT ABOUT 10 TIMES THE WEIGHT OR PRESSURE PER UNIT AREA AS A D-9 CAT WITH A BLADE -- THIS IS WHY STREAMBANK SHEAR NEEDS TO BE ADDRESSED

Light Grazing

Light grazing is usually not considered a grazing strategy. It is usually a component or constraint on some other type of grazing strategy. It can, however, be a grazing strategy in the riparian zone, especially under herding with sheep. The "Glossary of Terms Used in Range Management" by Kothmann (1974), defines light grazing. It is a comparative term which indicates that the stocking rate of one pasture is relatively less than that of other pastures. Kothmann states that light grazing is erroneously used to mean *under use*. This definition needs to be updated as the term light grazing will be more and more in vogue as a management tool in riparian areas. Pollen and Lacey (1979) define light grazing as using between 20 and 40 percent of the available forage.

Light grazing in this document means that amount of grazing that will cause no damage to the riverine-riparian system, and will allow riverine-riparian management objectives to be met.

CATTLE GRAZE RIPARIAN ZONES 20 TO 30 PERCENT HEAVIER THAN THE UPLANDS

Moderate Grazing

As with light grazing, moderate grazing is not a grazing strategy. The term is used to describe the amount of forage used which under moderate grazing can vary considerably, depending on the evaluator. Kothmann (1974) in the "Glossary of Terms Used in Range Management," defines moderate grazing as a comparative term which indicates that the stocking rate of a pasture is between the rates of other pastures. Kothmann states that the term is often erroneously used to mean proper use. I agree with Kothmann, as moderate grazing can easily exceed that amount of forage that would degrade riverine-riparian ecosystems. Pollen and Lacey define moderate grazing as utilization of between 40 to 60 percent of the available vegetation.

In this document the term "moderate grazing" is ignored as a strategy or a term. The term doesn't really mean anything. Many land managers try to use this term to imply that they are applying a BMP.

Heavy Grazing

PRESENT GRAZING STRATEGIES WERE DEVELOPED PRIMARILY FOR THE UPLANDS; THEREFORE THEY DO NOT WORK WELL IN RIVERINE-RIPARIAN HABITATS

As with light and moderate grazing, heavy grazing is really not a strategy but a descriptive term. It has in the past, however, been used as a strategy. Historically, heavy grazing has been one of the most common strategies ever used. This strategy has been and still is the demise of many western streams. Kothmann (1974) defines heavy grazing as a comparative term which indicates that the stocking rate of a pasture is relatively greater than that of other pastures. Kothmann states that heavy grazing is often erroneously used to mean overuse. I disagree with Kothmann, in that heavy grazing almost always means the resource is being grazed too much and resource damage almost always occurs. Pollen and Lacey (1979) define heavy grazing as utilization of over 60 percent of the available vegetation.

In this document heavy grazing means that the forage is being utilized over its capability to maintain itself. In turn it does not support a productive riverine-riparian habitat. The term "heavy grazing" needs to be eliminated, however, from the range vocabulary. What counts is a quantitative utilization figure, that can be related to the ability of the range to support this utilization. The term "heavy grazing" will be around for many years to come, however. Therefore, the user should use it in the terms that the land manager and the livestock operator would use it. If the terms light, moderate, and heavy are not eliminated, then we need to emphasize even more the need for specific quantitative utilization. We must be prepared to acknowledge that on some range types even light grazing is too heavy.

ESTIMATES OF FORAGE USE BY LIVESTOCK FOR A GIVEN PASTURE ON UPLAND RANGE SITES IS NOT AN ACCURATE INDICATOR OF THE FORAGE USE IN THE RIPARIAN ZONE.

Early Grazing

Early grazing begins at the time of range plant readiness or earlier. Cool season plant growth has peaked and warm season plants are beginning their growth. It ends when flowering begins on the key species. Grazing may be heavy in the early part of the growing season when green and nutritious forage is needed. Supposedly, plants can make adequate regrowth to allow full plant recovery, and little damage is done to the forage crop in following years. Early grazing should end at that phenological stage when regrowth will not produce ripe viable seed.

Late Grazing

Late grazing is complete nonuse until flowering of the key plant species. Late grazing is often used to trample seeds into the ground and eliminate coarse-standing plant materials. Materials are eliminated by being eaten or trampled into the ground. Late grazing should not occur until after seed ripe time. With grazing at flowering time, livestock will often selectively graze the flowers. This can preclude seed production which has been well demonstrated on bitterbrush. The period of maximum warm season plant growth is over. Some growth of cool season plants may again occur if moisture and soil temperatures are conducive to plant growth.

Year-Around Grazing

Year-around grazing is continuous grazing throughout the calendar year. Stockmen and land managers will often call this yearlong grazing. This was the commonly used strategy before the turn of the century. Severe winters, just before and after the turn of the century, caused most cattle and sheep managers to discontinue this strategy. In some areas of the Great Basin and the West, this strategy is still in use.

Long Duration Grazing

Long duration grazing is the opposite of any short-term grazing strategy. Again, the meaning of this term or strategy is in the mind of the user. For the term to be meaningful it must be bound by a time and season constraint. *In this document long duration grazing means the time period of grazing exceeds that of season-long grazing but is less than that of year-around grazing.*

Holding or Gathering

The holding strategy holds grazing animals on designated areas of land until it's time to move them somewhere else. They are commonly held for long time periods under heavy stocking rates. Holding differs from "closed herding" used by Kothmann (1974). Kothmann's definition relates primarily to the spread of a herd while grazing and the handling of a herd in a closely bunched manner to restrict the natural spread of the animals when grazing. Closed herding infers the animals are constantly moving. The holding strategy is different because it is more contained and animals have freedom of movement within the designated area. Examples include holding animals on private pastures, gathering animals in small areas for disease treatment, use of Forest Service and BLM administrative pastures, holding on lower elevation meadows until higher elevation areas are ready for grazing, containing animals for breeding purposes, and holding on areas until transportation to another area can be arranged.

Season-long Continuous

Season-long continuous grazing is stocking a pasture, allotment, or area annually throughout the complete vegetation growing season. Kothmann (1974) defines this strategy as grazing of a specific unit throughout a year or for that part of a year during which grazing is feasible. Grazing strategies other than season-long continuous are commonly called specialized strategies, because scheduled moves of livestock from one pasture to another are involved. This document does not honor this definition as specialized infers that the strategy practiced was designed for some special objective. This is not necessarily the case. A grazing strategy is a grazing strategy. It can be compatible in one situation and not compatible in another. The grazing strategy may not be compatible in any situation or it can be compatible over large land areas.

Season-long continuous grazing allows livestock to exhibit maximum forage selectivity and can minimize livestock disturbance due to gathering, moving, and quick changes in forage quality.

Hot Season

Hot season grazing is usually classified as from July through September, depending on latitude and elevation. In the Great Basin it would normally occur between about June 20 and September 10. The "hot season" is typified by desiccation of the forage base on upland sites. Air temperatures are sufficient to cause grazing animals to use shade. Animals also consume a greater amount of water at more frequent intervals.

Deferred (1 to 4 Pastures)

This strategy delays pasture grazing until the more important forage plants achieve a desired growth or regrowth stage or produce ripe seed. Kothmann (1974) defines this strategy as the use of deferment in grazing of a management unit, but not in a systematic rotation including other units. This strategy calls for the discontinuance of grazing on various portions of a range in succeeding years. This allows each portion to rest successively during the growing season to permit seed production, establishment of seedlings, or restoration of plant vigor. This strategy requires more fencing and cattle movement than the season-long continuous strategy. The benefit of this strategy is to be able to delay use during any critical period.

Rotation

Rotation grazing means that pastures or portions of the area are used at different periods of the grazing season. There is usually a predetermined pattern in the rotation of use. Kothmann (1974) defines rotation grazing as a system of pasture utilization embracing short periods of heavy stocking followed by periods of rest for herbage recovery during the same season. Generally used on tame or cropland pasture.

Rotation grazing does not have to have short periods of heavy stocking rates. It can have short or long periods of light stocking rates. Today, this strategy is being used more and more on wild rangelands, especially in combination with some other strategy.

Rest-Rotation (3 to 5 Pastures)

The rest-rotation strategy calls for a multi-pasture design where each pasture receives at least one year of complete rest during each grazing cycle. The strategy prescribes rotated and complementary treatments of season-long rest, early grazing, and deferred grazing. These treatments usually occur after seed ripe and during key times in vegetative development. This is an intensive system of management calling for extensive fencing and animal movement. Grazing is deferred on various parts of the range during succeeding years, allowing the deferred part complete rest for one year. The grazing load is then absorbed by the other pastures for that year. Three or more management units are required depending upon the physiological and phenological requirements of the vegetation involved.

Kothmann (1974) defines rotation grazing as a strategy of pasture use embracing short periods of heavy stocking followed by periods of rest for herbage recovery during the same season. Rotation grazing is generally used on tame or cropland pasture. Kothmann does not define rest-rotation.

Hormay (1970) describes rest-rotation grazing as giving one pasture at least one year of complete rest during the grazing cycle. Periods of complete rest are rotated among each of the pastures. The plan calls for resting a pasture during the vegetative growing period until seed ripe time in key vegetative species. The pasture is then grazed to trample the seeds into the ground for better germination and rooting. This pasture is then rested the following year to assure seedling establishment.

The following (third) year the pasture is grazed from the start of the grazing season. Grazing continues until the livestock are moved to the pasture which has been rested during the vegetative growing period until seed is ripe and needs trampling into the ground.

Each rest-rotation strategy is unique, as are most other strategies. In summary, there are three basic treatments in the application of rest-rotation grazing management: rest until seed ripe time, graze after seed ripe time, and rest for seedling establishment.

A minimum of three pastures are needed for rest-rotation grazing. Because of plant differences, such as seed production characteristics or vegetative growth conditions, there may need to be more pastures to accommodate needed treatments. In arid southwestern rangelands (southern Nevada) there are both cool-season and warm-season vegetative species and year-long grazing is customary. Five or six pastures may be necessary to provide the necessary rest periods and to buffer against the frequent drought conditions.

Each rest-rotation grazing plan needs to be developed for the specific on-the-ground vegetative species and grazing use situation. Rest in the proper amount and at the proper time is the key to the strategy. Hormay (1970) developed the concept to produce and maintain desirable forage vegetation so as to restore degraded rangelands. The amount of rest to restore plant vigor is the same on dry sites and wet sites. Stocking rates, seasons of grazing use and degree of grazing use can be left up to the grazing user (Hormay, personal communication). On public lands, however, the managing agency and the public can provide input to these aspects.

Short Duration-High Intensity

This strategy calls for rotating high intensity use over short periods. With modifications, this strategy is used within other strategies. An example would be the Savory Holistic Method, and the so-called "high utilization grazing" described by Booysen (1969) and the "non-selective grazing" described by Acocks (1966). This strategy uses forced utilization of vegetation via high stocking rates coupled with long nonuse periods. The "short duration" term stipulates high utilization of the available forage crop in one day to several weeks. This requires numerous pastures and frequent rotation of animals from one pasture to another. This strategy is sometimes used in a wagon-wheel arrangement. Several pastures radiate outward, like the spokes of a wheel, and are served by a central water supply.

Deferred rotation grazing and short duration-high intensity grazing are within the same basic type. Under deferred rotation strategies, one-half or more of the total allotment is grazed at any given time. The time period of grazing usually equals or exceeds the period of rest. Under short duration-high intensity grazing the animals only use a small portion of the area at any given time. Nonuse periods are much longer than use periods. The savory grazing method is similar. It differs in that this method calls for daily planning and inspection with a requirement of built-in flexibility, should range condition warrant sudden changes.

High intensity-low frequency grazing is very similar to short duration-high intensity, except that periods of grazing are typically longer than two weeks and nonuse periods are over 60 days. Because the former strategy has negative impacts on animal nutrition and forces heavy plant defoliation, it has been largely abandoned in favor of short duration-high intensity grazing.

Seasonal Suitability

This strategy restricts the use of vegetation to a specific season (Kothmann 1974). The range or allotment is partitioned into pastures based on vegetation types, plant condition classes, or accessibility conditions. The best pasture, from a livestock nutritional standpoint, is selected for use for each season of the year. This strategy has application in those rangelands having high elevation differences or different randomly distributed precipitation patterns. The strategy is sometimes called the "Best Pasture System." Higher fencing cost and increased frequency to move animals from pasture to pasture to fit seasons of use increases operational costs.

Deferred Rotation Grazing
(Usual Version)
fr. Marlow

Pasture 1

	Spring	Fall
Year 1	▨	
2		▨
3	▨	
4		▨
5	▨	
6		▨

Pasture 2

	Spring	Fall
Year 1		▨
2	▨	
3		▨
4	▨	
5		▨
6	▨	

Time Control Rotational Grazing

Time control rotational grazing is almost synonymous with short duration-high intensity. This strategy also calls for high stocking density and multiple pastures. Rapid herd movement is used to prune forage plants for maximum regrowth and to reduce animal concentration on preferred plants.

Merrill Pasture Method

The Merrill pasture method is also called the Merrill three-herd/four pasture system, commonly involving three herds and four pastures. Each pasture is grazed continuously for a year, and then receives a four-month period of nonuse. Over the four-year grazing cycle the period of nonuse in each pasture has occurred during all times of the year. This strategy resembles deferred rotation.

Savory Holistic Method

This strategy is often thought of as a heavy stocking method with frequent movement of animals dependent upon the growth cycle of the plants. The strategy is similar to short duration-high intensity. The major difference is that the holistic grazing method must include daily planning and flexibility to obtain the desired animal performance through the dimensions of time, number, and space (Steger 1982). Rather than light or reduced grazing, this strategy advocates heavy stocking and frequent movement according to the growth cycle of the plants, vegetation types, and other environmental conditions. The technique impacts the soils by hoof churning that breaks up the surface capping, trampling ground litter, increasing soil porosity, and encouraging seedling establishment. Testing and research to date are lacking in evaluating this technique.

Under holistic resource management, the manager learns to plan and manipulate components or tools to meet objectives. It is applied in conjunction with what is termed "Holistic Ranch Planning" (Savory and Parsons 1980). The plan is supposed to concentrate more on total ranch and business management than on the evaluation of the specific management tools (water development, fencing, reseeding) that must be applied before the grazing method is initiated. The major biological constraints of the Savory Method are that rest periods should be long enough to restore plant vigor between grazing periods, and grazing periods should be sufficiently short to prevent re-grazing of recently bitten plants (Skovlin 1984). The number of days that cattle are in a unit and the required days of rest from grazing, therefore, set the total number of units. The rate of key species growth is important in determining the number of grazing days (Skovlin 1984).

Deferred Rotation

Deferment involves delay of grazing until seed maturity of the key species being considered. Rotation is the movement of livestock from one area to another on a programmed basis. Rotation is an orderly sequence of use when some or all subdivisions (pastures) are both grazed and deferred during the same grazing

Deferred Rotation Grazing
(Alternate Version)
fr. Marlow

Pasture 1

	Spring	Fall
Year 1	▨	
2	▨	
3		▨
4		▨
5	▨	
6	▨	
7		▨
8		▨

Pasture 1

	Spring	Fall
Year 1		▨
2		▨
3	▨	
4	▨	
5		▨
6		▨
7	▨	
8	▨	

season or calendar year. Kothmann (1974) defines deferred rotation grazing as any strategy having a stocking density index greater than 1 but less than 2. This provides for a systematic rotation of the deferment among pastures.

Steger (1982) states that under deferred rotation strategies, half or more of the land in the strategy is being grazed at any given time. The time a pasture is grazed equals or exceeds the period of rest. In this strategy, at least one pasture is deferred during part of the grazing season. This deferment is then rotated among pastures (a minimum of two and frequently four pastures) in succeeding years.

This strategy is commonly used to graze one pasture during the early part of the grazing season and then graze the remaining pasture or pastures during the late part of the grazing season. The following year the pasture use sequence is altered so the early grazed pasture last year is deferred to late grazing this year. Also, the pasture that is grazed late one year is grazed early the next year which means the cattle are eating vegetation off as it grows -- and this could include seedlings if any ever occur.

Stuttered Deferred Rotation

This strategy is similar to deferred rotation in that one pasture is deferred for part of the plant growth period. This deferment period is rotated among pastures in succeeding years. Under a two-pasture design, the deferred rotation strategy grazes one pasture early one year and another pasture late. The pattern is then reversed the following year. In the stutter method, the sequence calls for use on one pasture early the first 2 years, and the use of the other pasture late the following 2 years, taking 4 years to complete the cycle.

Cool Season

Cool season grazing implies use during early spring, summer, fall, and winter, depending on latitude and elevation. During fall and winter, forage is often available on south-facing slopes. Sometimes temperature inversions and snow accumulations discourage livestock from using stream bottom areas. Stock can disperse into upland areas during cool season periods.

Winter Grazing

Winter grazing is grazing during the winter months. Recently the strategy has taken on the connotation that grazing will take place when plants are dormant and streambanks are frozen. Therefore, bank damage can be minimized. Winter grazing is actually a form of seasonal grazing.

Herding

Herding means all animals are under control of a person or animals (dogs) so they are accounted for within space and time. The movement and placement of the livestock is under control of the manager at all times.

Riparian Pasture

This technique may be a separate strategy or be used as part of or in combination with another strategy. Similar to the Seasonal Riparian Preference strategy, the riparian pasture places the selected stream-riparian habitat, or portions of this habitat, within one or more pastures (Platts and Nelson 1985d). Unlike the seasonal preference pasture that can become a working pasture within the grazing cycle, the timing and use of forage within the riparian pasture is set strictly to meet previously determined riparian stream objectives. The pasture can be grazed or rested on any given season or year depending on stream-riparian needs.

Riparian pastures are normally smaller areas of rangeland containing both upland and riparian vegetation. They are managed as a unit together to reach certain objectives. This is opposed to streamside pastures containing only riparian vegetation or other pastures managed primarily to achieve results in the upland areas. They can, however, vary from narrow areas to large pastures that encompass whole watersheds. To stock riparian pastures, usually part of the allotment herd is moved into the pasture at a specified time. Depending on stocking rates, the season of use, and amount of usable forage, livestock are removed from the pasture when riverine-riparian objectives have been met.

Seasonal Riparian Preference

Kothmann (1974) defines seasonal grazing as grazing restricted to a specific season. This strategy can be used within many of the other strategies to control timing of use in the riparian zone. Some type of animal distribution control, such as herding or fencing, is used to graze riparian habitats during periods of least impact. The manager must move animals into different areas or pastures as the grazing strategy calls for but must be able to utilize the riparian forage at selected times. A common management after fencing riparian areas is to use the area as a seasonal pasture. Also, riparian pastures are used briefly as gathering-holding areas during the end of the grazing season round-up activities.

Set-Back Pasture

A set-back pasture strategy is a pasture that is larger than a corridor but not usually as large as a riparian pasture. The pasture is of sufficient size to function as a grazing pasture. The set-back pasture is often used to isolate out only that part of the riverine-riparian system needed to meet riverine-riparian objectives.

Corridor

In this technique, all the stream-riparian habitat, or required portions thereof, are fenced to try to obtain rest or the application of a desired grazing method. Corridors are usually narrow bands of protected areas closely following stream location.

Double Rest-Rotation

Under this strategy, the area or pasture with the highest riparian and stream values receives twice the rest that would normally be applied during a commonly used rest-rotation grazing cycle. For example, in a three-pasture design, the pasture with the highest stream-riparian values is rested continuously for 2 years and grazed early or late the third year. Thus, it takes 6 years to complete the grazing cycle.

Nonuse

Nonuse implies that the area of concern will not be grazed for a long period of time. In some cases it may mean that it will be many years before the area is grazed again, or it may imply that the area will never be grazed again. This differs from season-long nonuse which implies that the use will only be eliminated during the present or coming season. Nonuse is actually a grazing strategy in itself.

Rest

This strategy calls for complete rest for at least one year. Kothmann (1974) defines rest as a period of deferment included as part of a grazing system, but does not give it a time limit. Rest eliminates all use by livestock.

Combinations

Creating compatible grazing strategies to function in the large diversity found among many allotments requires non-cookbook approaches. Often one strategy will not work over the complete area nor over the mix of plant and soil types. Combinations of strategies may be needed to build the compatibility needed. This is the way the first intensive grazing strategies were designed, and those that had wide application or were quite successful went on to acquire their own names. The planner should not be tied down to just one strategy when a mix is needed to meet objectives.

GRAZING STRATEGY DEVELOPMENT

INTRODUCTION

Livestock grazing strategies and related techniques have been developed to increase forage production, increase plant and litter cover, encourage growth of desirable forage plants, improve range condition, improve plant species composition, decrease soil erosion, and increase plant vigor on grazed lands (Holcheck 1983). Although these strategies should also benefit the fisheries in streams that flow through grazed lands, more information is needed to determine if the objectives are actually being met in stream-riparian systems (the complete stream and its surrounding riparian habitat) and whether they benefit fishery resources (the "fishery" refers to the fish and their complete habitat). Literature that reports evaluations of the compatibility of different grazing strategies with fishery resources is lacking (Meehan and Platts 1978).

Holcheck (1983) reported that, although grazing strategies have been a major focus of range research and management, range specialists still lack specific knowledge of the conditions under which individual grazing strategies give best results. This observation also applies to the status of fisheries research and management. Holcheck (1983) also found little difference in cattle performance (e.g., weight gains) and diet quality between the different grazing strategies (e.g., season-long continuous versus rest-rotation). With little clear-cut advantage from specialized grazing strategies on upland rangeland sites, there is little economic incentive for managers and users to change from one strategy to another. Therefore, benefits from grazing strategies designed to improve stream-riparian zones as well as fisheries must be demonstrated.

Problems

Historically, those range managers developing grazing strategies have not distinguished between the different plant community types on the uplands and those of riparian ecosystems. They have typically subjected both groups to the same grazing management strategy. This management approach is still commonly used and has caused serious fisheries problems because of the disproportionate heavy use of stream-riparian zones by livestock. Designing an original grazing strategy that considers all the variables of climate, soils, vegetation, livestock, wildlife, the stream, and all the other rangeland resources, takes work, experience, knowledge, and imaginative thinking.

Rangeland researchers and managers have had difficulty developing grazing strategies that counter the unbalanced animal distribution patterns that develop when livestock concentrate in stream-riparian zones. Holcheck (1983) noted that for any grazing strategy to work it must be tailored to fit the needs of the vegetation, terrain, class or kind of livestock, and the particular ranching operation involved.

Today's range and fisheries specialists must tailor grazing to fit the needs of streambanks, stream channels, water quality, and streamside vegetation. If the riparian area is the key to a productive fisheries, then the grazing strategy must meet the needs of the key vegetation species, whether they be ungrazable brushy species or palatable grasses. Managers must make decisions daily using the best information available. They do not have the luxury of waiting years for research to find a definitive solution.

Environmental Considerations

In formulating and evaluating a grazing strategy, many environmental conditions must be considered. Conditions such as channel resistance or vulnerability to erosion, overall range condition, topography, climatic fluctuations, riparian plant community types, or beaver are present or absent. Also, such things as class of livestock, salting and husbandry practices, and degree of grazing strategy compliance must be considered. Prognostic tools must be used to predict such things as the amount of ungrazed vegetation required to catch sediment during runoff events to build streambanks and rebuild aquifers, the complex of vegetation cover needed to minimize trampling damage and bank erosion, and the amount of brushy canopy needed in the future to control solar heat input into the water column.

This document provides the necessary information and background for the development of compatible grazing strategies. There is no need to wait on any further information at this time. The state of the art is well enough advanced for restoring degraded western streams and their contiguous riparian habitats.

What do we need to correct?

Streambank shear damage by hoof or head action

•

Streambank and channel erosion from exposed soils

•

Streambank caving from weight of animals

•

Adverse changes in vegetation species composition

•

Drainage of wet meadows or lowering of water tables

•

Reduced streambank vegetation

•

Excessive increases in solar radiation

•

Inadequate decreases in canopy cover

•

Adverse changes in water column and channel morphology

•

Changes in nutrient cycling

•

Changes in streamflow regimes and sediment transport

•

Increases in stream width and decreases in stream depth

•

Reduction of streambank undercuts

•

Reduction of vegetative overhang

•

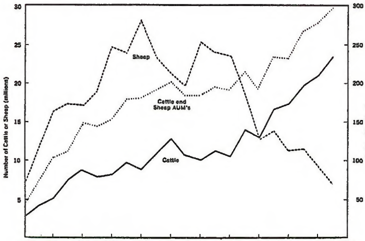
Proper Use

Proper use is often in the eye of the beholder and needs to be better defined. In this document, proper use is considered attained when the total vegetation available is grazed at a time and intensity that it does not degrade the existing riverine-riparian system, or in the case of degraded rangelands, the ability of the system to improve to a desirable state. Proper use on both the uplands and the riparian vegetation within an allotment is challenging. This challenge must be faced if the riparian zone is to be utilized for grazing.

Proper grazing strategies must recognize that livestock are selective grazers. Without control, preferred areas are always more heavily grazed. Because of the differences in vegetation preference between the uplands and the riparian habitat, and seasonally, most plants are grazed more heavily during one period than another. Plants react differently to defoliation at different times during their phenological development. The only way to counter the effects of preference is with an applied strategy that controls animal distribution and plant harvest timing. This means combinations of rotation and deferment, as livestock must eat everyday.

Strategies use rest, rotation, deferment, seasonal use, and combinations to gain this control. If animal distribution is under control, then stocking density and timing must meet proper use objectives.

Number of sheep and cattle and total livestock forage demand [1] in the 11 western states



[1] AUM's $= \frac{(\text{sheep} \times 12)}{5} + (\text{cattle} \times 12)$.

Source: U.S. Department of Agriculture Statistical Reporting Service data.

Kind and Class of Animal

In evaluating over time the effects of livestock grazing, and relating this to the design of a grazing strategy, it must be recognized that different kinds and classes of livestock have different preferences of use in regard to streamside environments. Sheep prefer slopes and upland areas, but cattle prefer riparian habitats. Cattle graze grasses more than sheep, with sheep utilizing more forbs and browse. Sheep are, or should be, attended by a herder who actively influences animal distribution and forage use. Cattle are usually left alone.

Much former sheep range has been converted to what is now primarily cattle range. Many of these ranges were better suited for sheep.

Cow-calf operations generally impact riparian areas more than yearling cattle. This is because steers and replacement heifers spend less time than cows and calves in the riparian areas. Seldom are the terrain and habitat characteristics considered in terms of which kind or class of livestock is most compatible. The kind and class is usually a given in the equation and depends on the type of operation the livestock operator is running.

Animal Distribution

Many livestock operators do not like to move their animals during the grazing season. It requires more labor and increases cost. Moving can cause a decrease in animal performance, depending on the increased handling and movement of animals, and the difficulty of the terrain. Sheep handle movement much more satisfactorily than cattle. Steers handle movement better than cow-calf groups. The strategy development must consider the movement of animals and many strategies are designed to create the least stress possible.

Animal distribution has to be controlled if any grazing strategy other than total rest is to be successful. There are many options to do this. Fencing is one of the most effective tools available, but is costly. Fencing can be used to either exclude or include livestock. Other options such as frequent riding, creating shade and water in upland areas, salt location, supplemental feed, rubbing posts and oilers can keep livestock away from riparian and drainage areas. Most of these options, except fencing, have little effect on keeping animals out of riparian zones. Bryant (1979) showed salting and even alternate water sources in the Blue Mountains of Oregon contributed little to drawing cattle away from riparian meadows. Frequent riding has little effect. Almost constant riding is necessary and good riders are extremely scarce and expensive. Herding is a positive solution and will be covered as a separate strategy. Season of grazing use influences grazing impacts on riparian areas. During hot weather, cows with young calves stay closer to water than during the cooler weather of spring and fall.

Strategy Design

There are many variables to put into the design equation such as the size of the area to be grazed, the length of the grazing season desired, the number of pastures to get needed management of the different diversities of habitats, the shape and arrangement of these pastures, type of livestock, water distribution, stocking rate, season of use, salting areas, and the operator's needs. The biologist should input any information available, but realize that the design is more in the hands of the range managers and the livestock operator. They have a better understanding of how livestock and lands mix. The biologist's input should be centered to the needs of fish and wildlife. This information needs to be made available before the grazing strategy and the range improvements are decided upon.

Design must be done with all resource goals in mind, but also meshed in with economic feasibility. For example fencing is expensive, and will increase allotment cost. Fencing design and amount must receive serious consideration early in the planning process. The use of existing fences must be maximized whenever possible in designing new strategies or modifying old ones.

In the design, salting should not be within one-half mile of the riparian habitat. Even though it has been found that salting has not been significantly effective in drawing livestock away from riparian areas (Kauffman and Krueger 1983; Wagnon 1963), salting needs to be done away from drainages and riparian areas.

Pasture design depends on many factors, such as kind and class of grazing animal, whether it's a riparian pasture, upland pasture, or a combination. In riparian pastures as much of the stream and riparian habitat should be included in the pasture as possible. Including small stream sections within upland pastures makes them hard to manage, as these areas are used intensively. Fence location should be determined keeping in mind that livestock concentrate near, and trail along fences, resulting in excessive trampling. Sometimes it helps to locate the stream as near the center of the pasture as possible, so livestock do not have to cross the stream for foraging or shading, but come to the stream only to water. Water does serve as a major focal point for livestock concentrations. Therefore, watering points should not be any farther than three-fourths to one mile apart. Water location is a tool, but not as effective as once believed. Kauffman and

Krueger (1983) did not find that off-site watering had much effect on drawing cattle away from riparian zones.

Because livestock select their grazing areas to meet many needs, the pasture design needs to consider these needs. The location of the grazed area is a function of the size and shape of the pasture, water location, desirable forage location, stocking density, supplemental feed if available, bedding grounds, salt, wind direction and intensity, and animal behavior. The rancher should be asked how his cattle graze and use the allotment. These are factors that only an expert range specialist or the livestock operator can provide. Biologists should identify and input fisheries and wildlife needs into the decisions on pasture design.

Options for Strategy Development

Seven major options must be considered when developing grazing strategies that incorporate fisheries compatibility. To be successful, control of combinations of one or more of the following is usually required:

1. Grazing frequency (includes complete rest)
2. Livestock stocking rates
3. Livestock distribution
4. Timing (season) of forage use
5. Livestock kind and class
6. Forage utilization
7. Rehabilitation (possibly artificial) of rangeland fisheries

Controlling animal stocking rates has been the principal option used in range management. Controlling numbers alone has had only limited success on stream-riparian zones. Rest is built into strategies such as rest-rotation to improve plant condition and seedling establishment. Deferred strategies use the timing of forage use to enhance plant vigor and seeding success. Some range specialists have never seen a deferred rotation grazing plan that has done any more than maintain a static condition, with no real improved benefits accruing to fish and wildlife (Hugh Harper, personal communication). The control of the kind and class of livestock can be highly successful but is seldom used. The artificial rehabilitation of rangeland fisheries should be a last-resort option. Natural rehabilitation under proper stewardship should receive first consideration.

Evaluation of Selected Grazing Strategies and Techniques

Each grazing strategy or technique discussed in the following chapter is evaluated with respect to how its use relates to potential impacts on fishery productivity (see Table II-1, p. II-26). Ratings range from 1 to 10. One indicates little or no fishery compatibility and 10 represents complete compatibility with fishery needs. Table II-2 (p. II-27) evaluates grazing strategies based on their effect on amount of streambank vegetation used, control of animal distribution, effects on streambank stability, ability to maintain brushy species, control of seasonal plant regrowth, and the ability of a stream-riparian habitat to rehabilitate while under the influence of the strategy.

The descriptions of the more commonly used grazing strategies are derived from the works of Kothmann (1974), Gifford and Hawkins (1976), and Holcheck (1983). The definitions used by Kothmann (1974) are used in this document whenever possible. The results of these researchers' work was also used to identify certain problems and benefits. Interpretations on corridor fencing, riparian pasture, rest, rest-rotation, double rest-rotation, and seasonal preference as related to fisheries needs were taken from Platts (1981, 1984), Platts et al. (1983, 1985), Platts and Wagstaff (1984), and Platts and Nelson (1985a, 1985b, 1985c, 1985d). This rating guide will need to be reviewed and refined over time, but for now it is something for a biologist to work with and closely analyze the results.

Those grazing strategy definitions that were listed in "A Glossary of Terms Used in Range Management" (Kothmann 1974) are used in this document. Kothmann does not define many of the commonly used strategies, so definitions from Holcheck (1983) and Gifford and Hawkins (1976) were used whenever possible.

The most promising grazing strategies for maintaining or rehabilitating riparian-stream systems are those that include one or more of the following options:

1. *Including a riparian pasture within a grazing allotment or operation to allow the riverine-riparian ecosystem to be managed separately from the uplands;*

2. *Fencing streamside corridors to allow stream-riparian habitats to rehabilitate;*

3. Changing the kind of livestock (from cattle to sheep on certain ranges) for better grazing compatibility with rangeland types;

4. Adding more rest to the grazing cycle;

5. Reducing intensity of use on streamside forage;

6. Controlling the timing (often season) of forage use so grazing occurs during periods most compatible with riverine-riparian ecosystems;

7. Managing grazing programs as specified and required in properly prepared allotment management plans or other proven management guides, thereby giving full consideration to riparian management objectives.

In reference to item (1), where cattle numbers are controlled to achieve desired forage use of the riparian vegetation, the utilization of upland forage normally exceeds that of the streamside forage by an average of about 13%--just the opposite of the typical allotment pasture (Platts and Nelson 1985c). Because they are usually drawn to moist sites, cattle will often override the grazing strategy if pasture size is too large for animal control. Also, no grazing strategy is going to work for stream fishery needs if there is not a set amount of vegetation left at the end of the growing season to buffer future ice and flood flows.

With item (2), corridor fencing, range and fishery specialists have attempted to solve problems by fencing stream-riparian habitats. Standard cost for two 30-meter-wide corridors is about $3,750 (U.S.) per stream kilometer, with $38 to $125 maintenance costs per stream kilometer per year. About 8 animal unit months of forage are lost per stream mile fenced (Platts and Wagstaff 1984). Fencing streamside corridors is a last resort, but it may allow those grazing strategies that are working well in the uplands, but not in the riparian zone, to be compatible over the watershed as a whole.

In item (3), class of livestock, there is opportunity, especially in the higher elevation areas, to change the grazer from cattle to sheep on those allotments where sheep grazing is more compatible. Proper herding, forage use, and timing of forage use can make this strategy completely compatible with fishery needs.

Item (4) calls for adding more rest to the grazing cycle. Holcheck (1983) has stated that the benefits from rest in one pasture may be nullified by the extra use that occurs on the remaining grazed pastures. Studies (Platts and Nelson 1985a, 1985c) tend to support this statement when use of the riparian forage is heavy. However, a three-pasture rest-rotation strategy can leave a vegetative mat on the streambank on 2 out of every 3 years, one year during early grazing and the other during the rested year. A double rest-rotation grazing strategy (1 year grazing, 2 years rest) has been successfully used on high elevation pastures (Platts 1984).

Items (5) and (6), intensity and timing of use, need more attention because the proper grazing of streamside vegetation requires tight control of animal distribution. In many areas it is not desirable or economically feasible to fence every streamside corridor to create corridors or riparian pastures (Platts and Wagstaff 1984). Therefore, grazing strategies must be developed that have better control over intensity and timing of forage use in riparian areas. Winter grazing, types of rest-rotation strategies, and deferments that allow protective mats to be maintained on the streambank during critical runoff periods show promise.

Item (7) calls for proper management of allotments, rangelands, or pastures, as required under the guidance plans. If grazed lands cannot be managed properly, as plans require, then no grazing strategy is going to work.

Biologists, working closely with range specialists, must analyze each grazing plan with respect to its compatibility with fishery-wildlife resources. Each plan must then be further evaluated to determine how well it meshes with basic and complete watershed needs. The stream and the watershed function as a unit. If the grazing management is not conducive to good watershed conditions, good stream conditions will also not exist.

Once they have deteriorated, many stream-riparian habitats are difficult to rehabilitate and need special management. In many situations, the stream-riparian habitat must be considered the key area for rangeland or pasture management. Livestock grazing under proper strategies with controlled intensities, timing, and animal distribution can include grazing use of riparian stream ecosystems and foster acceptable results. This move toward better rangeland management could easily give society the highest rate of return for time and money expended.

GRAZING STRATEGY COMPATIBILITY WITH RIVERINE-RIPARIAN ECOSYSTEMS

INTRODUCTION

Each grazing strategy or technique is evaluated with respect to how its use relates to potential impacts on fishery productivity (see Table II-1).

In Table II-2, each strategy is evaluated in terms of its influence on fisheries productivity and to a lesser degree on compatibility with wildlife. Each is rated using a range of 1 to 10, with 1 having little or no fishery compatibility and 10 being completely compatible with fishery needs.

Specialists have progressed slowly in evaluating grazing strategies with respect to fisheries needs. Our present understanding is rudimentary. Until an ecological classification system is placed on the ground to determine Best Management Practices, it will take time to attain sound conclusions on the best way to proceed. Managers do not have the luxury of waiting years for research to gather all the data and come up with a positive solution. Managers must make decisions on a day-by-day basis, using the best information and interpretation available. There is enough knowledge today that if it were put on the ground we would have all the tools and thinking necessary to bring western streams back to their once-productive state and increase the amount of forage now being used by livestock. This Guidance Document provides enough information and methods so that the move toward the rehabilitation of western streams can begin.

This document evaluates and interprets common grazing strategies, as they are used today, based on study and experiences. Future experience will refine and correct the weaknesses in these interpretations. The grazing strategies are described and evaluated on the commonly used stocking rates, grazing intensities, and season of use. Naturally, one cow grazing a large allotment at one percent utilization using any of the grazing strategies would be compatible with fisheries needs. This is why they were evaluated under commonly used methods.

Table II-1. Potential effects of grazing on aquatic and riparian habitats to be considered when grazing strategies or techniques are evaluated.

Streambanks

(1) Shear or sloughing of streambank soils by hoof or head action.
(2) Water, ice, and wind erosion of exposed streambank and channel soils because of loss of vegetative cover.
(3) Elimination or loss of streambank vegetation.
(4) Reduction of the quality and quantity of streambank undercuts.
(5) Increasing streambank angle (laying back of streambanks), which increases water width and decreases stream depth.

Water Column

(1) Withdrawal of streamflow to irrigate grazing lands.
(2) Drainage of wet meadows or lowering of the groundwater table to facilitate grazing access.
(3) Pollutants (e.g., sediments) in return water from grazed pasture lands, which are detrimental to the fisheries.
(4) Changes in magnitude and timing of organic and inorganic energy (i.e., solar radiation, debris, nutrients) inputs to the stream.
(5) Increases in fecal contamination.
(6) Changes in water column morphology, such as increases in stream width and decreases in stream depth, including reduction of stream shore water depth.
(7) Changes in timing and magnitude of streamflow events from changes in watershed vegetative cover.
(8) Increases in stream temperature.

Channel

(1) Changes in channel morphology.
(2) Altered sediment transport processes.

Riparian Vegetation

(1) Changes in plant species composition (e.g., brush to grass to forbs).
(2) Reduction of floodplain and streambank vegetation, including vegetation hanging over or entering into the water column.
(3) Decrease in plant vigor.
(4) Changes in timing and amounts of organic energy leaving the riparian zone.
(5) Elimination of riparian plant communities (i.e., lowering of the water table allowing xeric plants to replace riparian plants).

Table II-2. Evaluation and rating of grazing strategies based on author's personal observation, as related to stream-riparian habitats.

Strategy	Level to which riparian vegetation is commonly used	Control of animal distribution (allotment)	Stream-bank stability	Brushy species condition	Seasonal plant regrowth	Stream-riparian rehabilitative potential	Rating
Continuous season-long (cattle)	Heavy	Poor	Poor	Poor	Poor	Poor	1[a]
Holding (sheep or cattle)	Heavy	Excellent	Poor	Poor	Fair	Poor	1
Short duration-high intensity (cattle)	Heavy	Excellent	Poor	Poor	Poor	Poor	1
Three herd - four pasture (cattle)	Heavy to moderate	Good	Poor	Poor	Poor	Poor	2
Holistic (cattle or sheep)	Heavy to light	Good	Poor to good	Poor	Good	Poor to excellent	2-9
Deferred (cattle)	Moderate to heavy	Fair	Poor	Poor	Fair	Fair	3
Seasonal suitability (cattle)	Heavy	Good	Poor	Poor	Fair	Fair	3
Deferred rotation (cattle)	Heavy to moderate	Good	Fair	Fair	Fair	Fair	4
Stuttered deferred rotation (cattle)	Heavy to moderate	Good	Fair	Fair	Fair	Fair	4
Winter (sheep or cattle)	Moderate to heavy	Fair	Good	Fair	Fair to good	Good	5
Rest-rotation (cattle)	Heavy to moderate	Good	Fair to good	Fair	Fair to good	Fair	5
Double rest-rotation (cattle)	Moderate	Good	Good	Fair	Good	Good	6
Seasonal riparian preference (cattle or sheep)	Moderate to light	Good	Good	Good	Fair	Fair	6
Riparian pasture (cattle or sheep)	As prescribed	Good	Good	Good	Good	Good	8
Corridor fencing (cattle or sheep)	None	Excellent	Good to excellent	Excellent	Good to excellent	Excellent	9
Rest-rotation with seasonal preference (sheep)	Light	Good	Good to excellent	Good to excellent	Good	Excellent	9
Rest or closure (cattle or sheep)	None	Excellent	Excellent	Excellent	Excellent	Excellent	10

[a] Rating scale based on 1 (poorly compatible) to 10 (highly compatible) with fishery needs.

KIND AND CLASS OF ANIMAL

Different species and age groups of livestock graze watersheds in different ways, especially the riparian zone. Herded sheep usually use slopes and upland areas, while un-herded cattle prefer the lesser slopes or bottomlands. Sheep have been shown to exert a lesser influence on certain riparian and aquatic areas. Platts and Nelson (1984) found no significant diferences between grazed and ungrazed pastures on two high-elevation (about 6,000 feet) sites using sheep in a three-pasture, rest-rotation strategy, with good herding. They stated that this strategy with sheep using good herding could be compatible over many areas in the Cascades, and Rocky and Sierra Mountains.

The common practice over the past 50 years has been to convert sheep use areas to cattle use. This move is still on today. In the following strategy analysis, the descriptions, problems, solutions, and evaluations refer to cattle, unless otherwise noted.

IT HAS BEEN RECOGNIZED FOR 70 YEARS THAT HEAVY GRAZING ACCELERATES EROSION AND RUNOFF

-RICH 1911, DUCE 1918, SAMPSON AND WEYL 1918

PROBLEMS

The challenge in the near future is, can we implement grazing strategies that will halt or reverse the degradation on rangeland streams without reducing livestock numbers? Streams in the west are in their present degraded condition because many small, annual, degrading effects were cumulative over time. After 100 years they constitute major changes in riverine-riparian habitats. Land managers must not only administer their grazing strategies with finesse to meet today's needs. They must also correct the mistakes of the past.

Skovlin (1984) states that there has been no common goal for range managers who make decisions that affect riparian-stream environments. A prioritization of the best uses of the different classes of riparian-stream environments must be made prior to grazing strategy development.

Once the prioritization has been set within the objectives for management, then the basic impacts, such as the possible reduction in plant cover and vigor; increased trampling that causes streambank soil shear, plant damage, and soil compaction; and changes in plant species composition must be worked into the grazing strategy design. This must all be done knowing that it is not economically feasible to fence every streamside corridor and riparian pasture to control animal distribution. Grazing strategies must be used that will accomplish the same result.

SOLUTIONS

To implement a successful grazing strategy, basic principles of grazing, hydraulics, vegetation, soils, fisheries, wildlife, culture, economics, and various other needs must be understood and considered. Earlier, this document listed 7 options for designing a successful strategy that can be meshed with some of the most promising approaches for attaining success. These include a riparian pasture for separate management, fencing streamside corridors for rehabilitation, changing the kind and class of livestock to better fit terrain and vegetation needs, adding more rest to the grazing cycle, reducing intensity of vegetation use, controlling the timing of vegetation use, deferring for development of plant vigor and species composition control, and lastly and most important to assure management of the pasture or allotment as the plans say they are to be managed. Using these techniques will permit grazing use of riparian ecosystems with successful results.

> ***RIPARIAN AREAS HAVE USUALLY BEEN IGNORED IN THE PLANNING PROCESS BECAUSE THEIR LIMITED EXTENT MADE THEM "SACRIFICE AREAS"***
>
> **-SKOVLIN ET AL. 1977**

Pollen and Lacy (1979) have demonstrated from a number of grazing studies, that vegetation herbage production would increase 13 percent if grazing strategies were implemented at a moderate use level on western ranges. In addition, they showed that if intensity were reduced from heavy grazing to moderate grazing, and from moderate grazing to light grazing, vegetation herbage production would increase on these western ranges by a mean of 35 and 28 percent, respectively. This demonstrates how important utilization is in the design of a grazing strategy, and makes it one of the most important factors in gaining success.

Light Grazing

Light grazing, of course, is not a strategy, but commonly is used to describe how an area is being grazed. The term "light grazing" needs to be done away with. The refinement needed to develop compatible grazing strategies requires an accurate and economical measurement of vegetation use.

Moderate Grazing

Moderate grazing again is not a strategy, but is often used to mean that the grazing is compatible. Again, the old saying that every thing is fine if you "take half and leave half (moderate grazing) often does not work. Again we need to get to the actual vegetation use for designing grazing strategies.

Heavy Grazing

Heavy grazing is another vague term. In a short duration-high intensity strategy, heavy grazing could be defined by some users as an excellent way to go. In many other strategies it would mean grazing that will do much damage. We need to define the actual vegetation use and get away from modifiers.

Early Grazing

Early grazing is often used as a strategy, especially on ranges with early green up, where moisture continues to allow regrowth after grazing ceases. The success of this strategy is dependent upon ending early grazing in time to allow plants to mature and gain seed ripe. On many ranges, early grazing means to be on the pasture at first plant readiness, and leave at the end of plant growth. Thus, plants are overgrazed, and the strategy seldom works. Also, streambanks may be in their most tender state because of high moisture soil content.

The success of this strategy is in qualifying the time period for early grazing, then setting the duration to meet the physiological needs of riparian plants and physical needs of the streambanks. Spring use can result in better livestock distribution between riparian and upland areas because of riparian area wetness or flooding. There is more lush cool-season forage in the uplands.

Late Grazing

Late Grazing is also often called deferment or late season deferment. Grazing strategies which incorporate late grazing deferment can offer a good measure of protection without great expense (Skovlin 1984). Late Grazing can be easier on vegetation because most plants have completed growth and perennial plants have completed their root storage of carbohydrates. Diets can shift, however, to woody species in the animals' search for greater amounts of protein. Late grazing is sometimes used to coincide with fall climates. During this period cattle have a tendency to move into the uplands as cold air pockets form in the valley bottoms. Elk also behave according to this principle. Topographic conditions and climatic conditions have to be just right to make this happen. In many cases, cattle will remain on the valley bottoms during this period because it contains the only green vegetation within the allotment. I have, however, seen glaciated valleys where late season grazing would be compatible, because the cold air pockets form early and remain in place.

Marlow and Pagacnik (1986) have decreased streambank damage by using late season deferment. Streambanks are grazed when soil moisture content is usually less than 10 percent, and are therefore much more resistant to trampling damage. Again, late season grazing shouldn't be used by itself unless qualified with timing, intensity, and valley form. It is better to work late season grazing into one of the deferment strategies, with better definition of application and restrictions.

Year-Around Grazing

Year-around grazing is exactly what is says. Because it only remotely has any chance of success it should be stricken from our vocabulary. It will not be discussed further. Allotments I have observed in Nevada (Ely area) under year-around grazing have been disasters. Yet they still continue under this type of management today.

Long Duration Grazing

Long duration grazing implies that the livestock are there for a long period of time, almost always too long. This is another term that should go by the wayside and not even be considered.

WE MUST LEARN FROM OUR PAST MISTAKES AND NOT REPEAT THEM IN THE FUTURE

Season-Long Continuous

Season-long continuous grazing allows livestock to linger on riparian areas and streambanks because of the convenience of forage, water, terrain, and cover. Preferred plants and riparian areas receive excessive use even under light stocking rates. The continuous regrowth of riparian vegetation keeps livestock on streambanks during the complete growing season.

There are positive benefits to season-long grazing, but these are mainly to the benefit of the livestock operator. The strategy does allow livestock to exhibit maximum forage selectivity, which can be good or bad. Costs of operation are kept to a minimum, as it requires little fencing. Operators like this strategy because it reduces livestock disturbance due to gathering, trailing, and sudden change in forage quality.

SELDOM WILL SEASON-LONG CONTINUOUS GRAZING BE COMPATIBLE WITH FISHERY RESOURCES AND SHOULD BE DISCOURAGED WHENEVER POSSIBLE

This grazing strategy is seldom compatible with fishery resources under commonly used forage intensity and seasons of use. The reason is because too much pressure is exerted on riparian plants and streambanks (Platts et al. 1983, 1985; Platts and Nelson 1985b). The palatable species (e.g., carexes) are frequently grazed and therefore become overgrazed. This leads to their elimination from the streambank. In many areas of the West this has allowed Kentucky bluegrass or unpalatable grasses, forbs, and shrubs to take over streambanks and adjacent floodplains.

Roath and Krueger (1982) in the Blue Mountains of Oregon, found that a large percentage of cattle grazing days and accompanying vegetation utilization on the riparian zone occurred in the first 4 weeks of the grazing season. The riparian zone produced 21 percent of the forage, but only made up 1.9 percent of the total land area. The riparian zone making up less than 2 percent of the area produced 81 percent of the livestock forage. They found that fall rains and the formation of cold air pockets can give the riparian area some relief later in the season. These temperature inversions cause cattle to have more interest in the upland slopes, especially south slopes.

The primary problem with this strategy is that livestock have preferred plants and areas for grazing. Thus such plants and areas receive excessive use even under low animal stocking rates. Cattle will congregate on those areas where water, forage, and cover are found closely together. Also, the location of livestock turn-out is usually in the flatter, lower areas. These coincide with riparian areas, and this again can lead to over utilization of the area. Sufficient precipitation during the plant growing season to cause regrowth after grazing can help buffer the effects of this strategy. Food reserves depleted by the regrowth, however, need to be fully restored. This does not occur until after ripe seed has been produced. Also, this strategy works better in flat terrain where water sources are less than one-mile apart in any area of the allotment. Another way to try to make this strategy work is to fence the sacrifice areas that have developed or will develop. This can, however, cause new sacrifice areas to develop somewhere else.

Holding

The holding strategy, although commonly used, is seldom compatible with riverine-riparian systems because season of use and proper utilization receive little consideration. When sheep are held on riparian areas they adversely affect these areas much the same way cattle would (Platts 1981). Holding affects the riverine-riparian system much the same way as season-long continous grazing.

The holding strategy should only be used in areas that are designated as "sacrifice areas." If used in separate units, or if within pastures that are part of a allotment, then the holding grazed area should meet the same objectives as any other well managed allotment. Utilization and timing must be carefully controlled to keep grazing under a holding strategy compatible with other resources.

Hot Season

Hot season grazing usually takes place at the same time desiccation of forage on the upland sites takes place. Upland plants usually dry up because of low soil moisture and heat stress. The riparian forage may still be lush and highly desirable. Livestock have a higher demand for water and shade. This is the period of maximum warm season plant species growth and diminishing growth of cool season species.

Meyers (1982) in Montana found that there was no correlation between the grazing strategies studied and riparian condition. He did, however, find that the amount of vegetation used during the hot season was important. Vegetation regrowth was poor when grazed during the hot period. Meyers recommended that grazing not be allowed more than once in a four-year period during the hot period. This would exclude a 3-pasture rest-rotation strategy.

Annual hot season grazing is another type of strategy that needs to be abolished. If used it must be closely worked into another strategy in a manner that will control utilization during this period. Hot season grazing should not be considered as a compatible grazing strategy for riverine-riparian systems. Under commonly used approaches it has little chance of success.

Deferred (1 to 4 pastures)

Deferment allows opportunities to improve plant vigor and cover, especially for the preferred grazing plants. Under this strategy plants have a better chance to gain necessary growth to set seed and maintain root structure. More even animal distribution occurs over the complete pasture than with season-long continuous grazing. Animals are easier to gather in the fall because they wind up in a more confined area.

This strategy can be especially effective where considerable differences normally exist between the consumption of different plant species and accessibility of plants to be grazed. The deferment adds periods of nonuse that can improve the capability of the vegetation to protect streambanks from erosion. To be successful, however, a sufficient amount of herbage needs to remain at the end of each grazing treatment for fisheries needs, especially at the end of the late grazing period. Some positive effects of late season deferment are: (1) Soils are dryer and less susceptible to compaction; (2) plants have already taken on their carbohydrate reserves; (3) seeds have been set; (4) trampling may benefit some seed establishment; and (5) the riparian vegetation has higher nutritive value than upland forage at this time.

YOU HAVE TO BE CAREFUL DURING THIS PERIOD BECAUSE SHRUB UTILIZATION IS HIGHEST WHEN HERBACEOUS VEGETATION IS DRY, COARSE, AND MATURE.

Elmore and Beschta (1987) reported that holding cattle off riparian areas until late summer, allows nesting birds and small mammals to complete critical activities associated with reproduction. The growing season is over so late grazing impacts on vegetation are minimal. It is most important to make sure enough vegetation is left on the streambank to keep streambank maintenance and building processes operating.

Smith (pers. comm.) on his allotment near Rock Springs, Montana, has used deferred grazing together with good herding to improve riparian and fish habitat. The key here is "good herding" and this is important to a sucessful strategy. By itself, deferment will seldom bring back badly degraded riverine-riparian habitats. In combination with another grazing strategy that provides careful control of grazing use on the streambanks, deferment can be a valuable tool. The key to deferment in maintaining riparian habitats, if it is used by itself, is to have controlled degree of forage use within the riparian zone.

Heavy use during the late period of deferment can remove the vegetative mat needed to protect streambanks from ice and water scouring. Higher animal stocking per pasture because of more animals per unit area can cause additional streambank shear during the first part of the grazing season.

Rotation

Rotational grazing strategies work best when the recovery time stipulated is sufficient for complete plant recovery. Rotational grazing on extensive land areas, even under light stocking rates can impact riparian habitats, because of concentration of animals in preferred areas. Rotation can provide wildlife benefits by creating pastures with diverse vegetation height and with some residual vegetative cover for both nesting and escape from predators. When stocking density is high, livestock performance may suffer because of competition in a smaller space and constantly moving to find sufficient forage.

Rotation by itself seldom works for improving riverine-riparian systems. It is a valuable technique when meshed into other strategies such as rest-rotation, double rest-rotation, and stuttered deferred rotation with a riparian or set-back pasture.

Rest-Rotation (3 to 11 pastures)

Since Gus Hormay (1970) constructed the first rest-rotation grazing strategies in the 1950's, they have swept the West. For the first time a widely used strategy included rest throughout the complete growing season. Although constructed for the uplands, this strategy, because it includes rest, has some possibilities for riparian systems. Hormay, in personal communication, stated that, "Vegetation in meadows and drainage ways is closely utilized under any stocking rate or system of grazing. Where this is the case, about the only way to preserve recreational values is to fence the area off from grazing. Reducing livestock or adjusting grazing seasons usually will not solve the problem."

This strategy increases stocking densities on grazed pastures if stocking rates are the same as with previous grazing techniques. This then must be offset by a complete year's rest every third year (in a 3-pasture design) to provide increased opportunity for seed production and seedling establishment. The year of no grazing gives seedlings a chance to be established and older plants another season to gain vigor and produce seed. Nongrazing during the late period of the plant growing season can allow regrowth, enhance food storage in the roots of perennial grasses, and foster better growth the following year. The late grazing period of the cycle enhances seedling establishment success and prevents grazing on the pasture too soon.

It is obvious that a change from a season-long continuous strategy to one with rest will stimulate range improvement.

A problem with rest-rotation is that benefits from the rest may be nullified by the heavy use that may occur. On pastures grazed over each grazing cycle, livestock would be grazing streambanks during the complete plant growing season. Compared to more simple strategies, some operators do not like the method because there are more forced animal movements. Livestock numbers may also have to be reduced to reduce excessive grazing on riparian areas. Because of the number of pastures required considerable fence construction and maintenance is required.

In one out of three years the streambank vegetative mat that is needed to buffer erosion is removed. In one out of three years livestock are on streambanks when soil moisture is high, and this can cause excessive shear damage.

Rest-rotation grazing has been blamed for reducing cattle health and red meat gain due to reduced grazing selectivity and forced animal movement from pasture to pasture. Work on the Starkey Experimental Station in the Blue Mountains of Oregon has found that this is not necessarily the case. Rotation grazing did not differ in results from two other strategies tested. Another negative factor is that permittees or owners do not believe that leaving a portion of the range ungrazed makes good sense. They consider this as forage forgone. They try to make up for this by taking Hormay's (1970) recommendations to heart. Because of the added rest you can hit the forage heavy the two years the pasture is grazed. This works on some upland vegetation but not on riparian vegetation. Riparian vegetation has to provide the buffering for the stream every year. Rest-rotation seems to work best when precipitation exeeds 15-20 inches per year with some of this precipitation coming during the summer hot period. Deserts like the Great Basin usually do not meet these requirements as they get less than 8-10 inches per year. Desert areas should never be grazed on more than 50% of the current year's growth because of the long time period needed for recovery.

Positive factors of rest-rotation are the long rest period which allows plants and streambanks to recoup from past damage. Two out of every three years the vegetative mat is left to buffer erosion and two out of every three years livestock are not on streambanks during their highest shear potential. Streams that have high natural rehabilitative potential can adjust and those that do not continue to degrade. Success lies in providing the amount of rest needed to match the stream's capability to repair past damage and also to maintain a vigorous riparian habitat. This is very important and often ignored. The amount of rest assigned has to fit the objectives of the allotment. Sometimes this amount of rest is much more than range managers will program into a rest-rotation strategy.

Rest-rotation can provide small mammals and upland game birds a good vegetative cover throughout the year in the ungrazed pastures. The rest and late grazed pastures provide waterfowl with the next spring's nesting areas. Pastures grazed early make good feeding areas for geese. Big game animals are well known for their ability to find the rested pastures.

Hormay (1970) stated, "That vegetation in the rested pastures is a form of insurance and may be grazed under adverse conditions." An example is in years of unusually low forage production. This is not true for the riparian zones unless they are already in excellent shape. Because they take the brunt of the grazing, they need more rest than the upland areas do. Platts and Nelson (1985b) found that in pastures with rest-rotation grazing the riparian types were grazed more heavily. Overuse of the riparian areas is about all that has kept the public range grazing going for the last 3 years. This environment is now showing the results.

Many failures and many successes have been reported using rest-rotation grazing. Some of the successes were in Montana in Lew Myers work (personal communication). There Myers modified a rest-rotation strategy that was keeping livestock in the pastures from 60 to 90 days, down to 20 days, thus providing growing season rest in all years. Davis (1982) reported good results in the Tonto National Forest in Arizona by going to a rest-rotation strategy. The change in strategy was accompanied with a 50 percent reduction in livestock utilization. In the White Acorn

Allotment in the Green River Resource Area of the BLM, good results were obtained with rest-rotation and excellent cooperation with the U. S. Forest Service and permittees. This was combined with much more frequent supervision of range condition and trend.

There are four ways to make rest-rotation grazing work. One is to use it only on those riverine-riparian complexes where the *channel* and the banks are controlled or can be controlled by vegetation. The second is to apply all the rest necessary to get complete stream rehabilitation to correct for the two years of high utilization grazing. Third is to modify into a double rest-rotation strategy with proper grazing use. And fourth is to change from cattle to sheep with good herding. Platts (1984) found that with sheep and good herding this strategy could be very successful.

Rest-rotation grazing by itself usually does not work in most riverine-riparian complexes. For success it must be combined with some other strategy to gain better control of vegetation use in the riparian. Seldom are riparian areas in good enough condition to take the same amount of use as the upland vegetative species. Seldom do they take less use; they almost always take more. In fact, it is not uncommon with unhampered vegetation selection by the cow to have riparian areas receive 80% utilization and the upland areas less than 5%.

The sample grazing strategy below was designed to increase the frequency of bitterbrush and blue-bunch wheat grass. Many of the requirements also fit riparian vegetation needs. Bitterbrush seed is produced primarily on the previous year's twig growth. Therefore, the previous year's growth must be preserved. The advantage of this strategy over double rest-rotation is that it can benefit both the uplands for wildlife and the riparian area for both wildlife and fish. Double rest-rotation in some habitat types may not provide all the rest needed.

Example of a 4-Pasture Rest-Rotation Strategy

TREATMENT	APR	MAY	JUN	JUL	AUG	SEP	OCT
1989 A		*****	*****	**"**			
1990 B				"			
1991 C				"**	*****	*****	*****
1992 D				"			
1993 A		*****	*****	**"			
1994 B				"			

LEGEND

***** = GRAZING PERIOD

= REST FROM GRAZING

“ = SEED RIPE TIME

Short Duration - High Intensity

This strategy is sometimes called high-intensity low-frequency, high utilization grazing, nonselective grazing, holistic grazing, short duration grazing, time controlled, or the Savory method. Whatever the name, it is a method which requires intensive managerial input by the livestock operator or the land manager. Proponents claim dramatic improvements of rangeland (uplands) condition, if proper implementation is made. There is an implied claim that both the rate of rangeland improvement and individual animal performance is enhanced at the same time that stocking rate is increased (Savory and Parsons 1980). Proponents claim that the physical trampling damage by the concentrated animals is not detrimental, but hastens plant succession to better species.

Better grazing distribution is gained by fencing large areas into smaller units for control of animal distribution and grazing intensity. The method usually uses more than 5 pastures, often in a wagon wheel cell arrangement. It uses about 30 to 60 days of rest between grazing periods (Savory 1978).

A major advantage of this strategy over season-long continuous is improved livestock distribution resulting in balanced forage utilization. If there is an advantage to riverine-riparian habitats, it would be in the long rest periods. To date there is little information on its compatibility with streams. Pastures we used this strategy on showed adverse impacts on streambanks. The intensive hoof churning can definitely destroy the cryptogamic soil crusts. Some claim this can lead to beneficial range condition. The resulting intensive shearing and trampling of streambanks, however, usually lays them back to much greater angles. Thus, fish biomass will usually decrease.

THE FORAGE YOU HAVE REMAINING AT FROST IS THE ONLY FORAGE WILDLIFE WILL HAVE UNTIL SPRING, THE MOST CRITICAL PERIOD OF THEIR YEAR.

This strategy requires frequent periods of precipitation, preferably season-long, for plant regrowth. Too much grazing and mechanical pressure by livestock is placed on brushy species, and resulting damage is usually severe. The strategy was designed to force uplands to produce grass, not brushy species. The intensive grazing during periods when streambanks have high soil moisture content are the primary cause of mechanical damage.

One of the major problems with the method is that livestock are stocked to capacity during the favorable years. This means pastures are grazed above capacity during below-average or poor years of vegetation production. Therefore, the rangeland is usually overstocked in all except the very best years (Heilschmidt 1988). This factor applies to almost all presently used grazing strategies and the drought years of 1987 and 1988 really brought this home. Many western riparian rangelands took a beating during this period.

Short duration-high intensity grazing works best on flat grassland areas which have an extended period of growth because of summer rains. The Great Basin is not known for its summer rains. In the Great Basin and other areas of the West, concentrating large numbers of animals in the early part of the growing season usually results in severely trampled streambanks. This is caused by compaction of the wet soils, and frequent shearing of the streambanks. The area's early snowmelts and heavy spring rains just do not lend themselves to large concentrations of animals confined on small areas. Spring growth periods come and go quickly. Suddenly the ranges are in drought condition and there is little chance for regrowth once the plants are defoliated by livestock. The forage you have remaining at frost is the only forage wildlife will have until spring, the most critical period of their year. Fall rains can encourage regrowth. This regrowth, however, depletes stored food reserves which are not usually regained if the regrowth is grazed. The cost of using this fall regrowth is lack of over-winter plant survival and reduced growth the following spring.

Short duration-high intensity grazing was initially designed for irrigated pastures or constant precipitation areas. This strategy should probably be confined to those areas. In the Great Basin range types, as the intensity of defoliation increases, the capacity of the riparian plants to grow and maintain themselves decreases. The short grazing periods with large concentrations forces the animals to remove most of all the available forage without selection. So there go the willows. This strategy is quite successful on good-condition crested wheat mono-culture seedings.

For riverine-riparian management, crested wheat seedings are not all that compatible. They can, however, take pressure off riparian systems. Management track record shows that seedings are usually put in place to increase stocking rates rather than reduce grazing pressures on native rangelands.

In summary, if this strategy is used on an allotment or area of land, about the only alternative for protection of the riverine-riparian habitat is to isolate out the riparian zone and apply some other type of grazing management to it. Short duration-high intensity should never be recommended for riparian areas. Short duration-*low intensity* appears to be a favorable option.

Seasonal Suitability

This strategy increases fencing costs and the necessity for movement of animals from pasture to pasture. Also, this strategy was designed to increase red meat production. The riparian habitat could easily be selected at the wrong time of the year as the "best pasture" to have the livestock in. Thus, it would receive heavier use during periods where streambank damage occurs more readily. The strategy does, however, provide some deferment from grazing during selected periods of the grazing season. This allows selected periods of nonuse to allow degraded streambanks and riparian vegetation some time to recover. Because each pasture is grazed every year, there is no rest applied and the programmed nonuse will probably be inadequate.

This strategy calls for moving livestock to those pastures containing the best available forage. In Great Basin types, this means the riparian areas could constantly be selected, especially during summer and fall. Also, riparian areas have a much longer growing season because of the continuance of soil moisture throughout the season.

If riparian-stream areas were the main consideration and the best season of use were applied just to the riparian areas, then this strategy would hold some promise. At certain times of the year, in certain riverine-riparian complexes, cattle prefer upland areas away from streams. This often happens in the early part of the season when the riparian areas are too wet, and in the fall when they are too cold. Also, soil compaction and streambank shearing from hoof action varies. This varies with soil type, but also with the amount of moisture in the soil, which is usually a function of season.

I would suggest that you ignore this strategy for riparian areas. Livestock would be grazing during periods when brushy species are utilized more heavily and streambanks are more susceptible to damage. Meyers (1981) has shown that 10 to 12 years on non-used or better managed pastures is still insufficient for recovery of a degraded willowed riparian community. I have found that some riparian habitat types will take even longer than this, probably due in part to what gulling of the streambed has done to adjacent water tables.

Time-Control Rotational Grazing

This strategy is the same or similar to short duration-high intensity (SDHI). The term is used by the BLM, in many areas, instead of SDHI. The name "time-control rotational grazing is usually shortened to just "time control." This strategy also varies the grazing period according to the stage of plant growth. The main purpose is to put enough cattle in a restricted area so that the less desirable plants are grazed at the same rate as the desirable plants. Because of the extensive, concentrated grazing, each pasture being grazed has to be watched constantly to prevent overgrazing. Overgrazing can occur very quickly. This strategy calls for much more fencing, and operating and maintenance costs are higher. Many more vehicle miles are put on and constant riding is required to make the method work. The strategy has much less flexibility than most other grazing strategies.

The extra riding and inspections have a positive side also. Sick animals are given much quicker attention, animals caught in fences or bogs are released sooner increasing survival rate, and less forage is wasted. Lew Meyers (personal communication) has seen improved riparian conditions using this strategy. I have seen the opposite and it probably depends on what riverine-riparian complexes are being grazed. The specific grazing management that is being applied will also determine its success. This strategy needs more observation under different habitat types to determine its importance in bringing back western streams.

Merrill Pasture System

The Merill Pasture System is often called the three herd-four pasture strategy. The advantages of this strategy are that the period of nonuse in each pasture has occurred during all times of the year at the end of a four-year cycle. The strategy has given good results in the uplands where effective precipitation and plant growth occur at any time of the year. It has not been tested or proven in riparian systems. In Texas it has been found superior to season-long continuous grazing from the standpoint of livestock forage and wildlife production. The strategy calls for less animal handling than many of the other intensive strategies. Higher plant production has been gained with this strategy over other strategies, providing sufficient precipitation occurs during the entire year.

This strategy is not good for riverine-riparian habitats as livestock are grazing streambank vegetation during all periods of the year. Thus, they are on streambanks most of the year. Early grazing causes additional streambank shear. Late grazing can eliminate the vegetative mat that protects the streambank from the next flooding or ice event. Constant grazing can occur on brushy plant species, especially during the continuous grazing year. Only one four-month period of nonuse out of the four-year cycle is insufficient for rehabilitation of the fisheries habitat.

This strategy was developed for the uplands and that is where it should stay. At this time, under commonly used management, it should not be used in riverine-riparian habitats.

Savory Holistic Method

Neither the holistic or the short duration-high intensity strategies have been studied long enough on riverine-riparian habitats to draw final conclusions. There have been, however, a few documented successful demonstrations. Supposedly, the hoof action and mechanical disturbance of soils will improve infiltration, decrease overland flow, and promote better riparian zones by reducing peak streamflows. Any management strategy that would return Great Basin streams to natural flows, would be a great improvement.

Hooves breaking up the soil crust also incorporates manure, litter, urea, and seeds into the soil surface. The hoof prints form seed beds and pockets for collection of litter and precipitation where seeds are compressed in mineral soil. Pruning the plants by grazing, trampling, and crushing stimulates new plant growth. The claimed herd effect of doing so much good for infiltration or decomposition of litter may not actually be true. These processes, such as hoof churning in riparian habitats, can actually decrease infiltration by soil compaction and the pruning accomplished by grazing may eliminate brushy species by over-pruning.

The theory behind going to the Savory grazing strategy after those already tried have failed, is that nearly all presently used grazing methods today result in understocking and overgrazing. The Savory method supposedly controls grazing by controlling time rather than with numbers of animals. This requires intensive animal movement. Some range experts claim that paddocks should not be grazed more than 7 days and then allowed to rest 35 to 60 days. This type of grazing then requires a great number of paddocks or pastures. Some operations have over 100 pastures to get the needed rest between grazing periods. In riparian systems it is not known at this time what the period of rest should be between grazing periods to keep morphological form from changing.

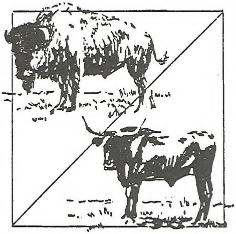
The biological constraints to the holistic strategy are that rest periods should be long enough to restore plant vigor between grazing periods, and grazing periods should be sufficiently short to prevent regrazing of recently bitten plants. To properly apply the strategy one must understand what is meant by a "brittle or a "non-brittle" environment. "Brittle" environments are defined as those areas of the earth characterized by prolonged periods of adverse plant growing conditions. I could never grasp the concept of "brittle and nonbrittle" and tried to work with it by visualizing a "brittle" environment as one where the elimination of grazing would not result in the natural rehabilition of the range. Any environment that will improve once cattle grazing is removed is a "non-brittle" environment. I have seen very few "brittle" environments.

One excellent feature of the holistic strategy is that the livestock operator is forced to think about management options and possible responses. Daily supervision is a must. Few grazing techniques require this degree of sophistication or this amount of training. The operator, however, will still have difficulty determining needed forage use, forage timing, and animal movements. These have to be keyed to imprecisely defined environmental conditions requiring intensive training and more of the operator's time than is usually available. Savory contends that no one can operate his method without going through an intensive training course. If the method is so hard to install and operate, then even progressive ranchers, land managers, and extension agents are going to have problems initiating one and keeping it operating successfully.

A lot of the management of this strategy is still in the "eye of the beholder." Using livestock hooves to churn the soil, break the surface soil capping, trample ground litter, disturb soils for increased soil porosity, eliminate the biologic crust growing over many Great Basin soils, and encourage seedling establishment, is still to be done successfully in riverine-riparian habitats. Such conditions do not necessarily meet the needs of maintaining streambank stability, streambank morphology, channel form, and brushy vegetation.

The strategy was tested by Savory in Zimbabwe, Africa where it was patterned after big game animal grazing, such as the wildebeest. The thinking was that vegetation grazed in a manner under which it had evolved would be good management. Heady et al. (1974) also concluded that implementing grazing patterns as near as possible to those under which the vegetation developed would increase vegetation production and decrease grazing damage. Proponents of the holistic strategy claim cattle are the most available tools for recovering abused land and to help water, nutrient and mineral cycles to regain their proper functioning.

Cattle are claimed to be the ecological replacement in the United States for the vanished bison and other large wild grazing animals. Many range managers have tried to apply this reasoning to the Great Basin, not realizing that Great Basin vegetation was grazed relatively little by big game animals in recent geologic history. The main grazers were insects and small mammals.



The holistic method does, however, have excellent possibilities for improving streams in the Great Basin, providing the manager abides by the goals and objectives set out in the beginning for stream-riparian habitats. To do this means having the flexibility and options to make this type of strategy work. Most allotments on public and private lands are too small and homogeneous to provide the options needed to make this method work. Good success has been gained on some large ranches with no blocks to needed options and *no* red tape to get in the way. Because of political and bureaucratic hang-ups on public land, I believe this strategy has little chance of success on these lands. Possibly in the future if these restrictions fade away, this strategy may have its place in bringing back western streams.

Skovlin (1984) investigated the success of this strategy in its early beginnings in Africa, and gave the results bad marks. Users of this method should give all the evidence serious consideration before determining if this is the best method for their operations.

Deferred Rotation

This strategy has commonly been used to graze one pasture early and the other pasture late. The sequence is then rotated the following year. This strategy can also be used for multiple pasture designs calling for more than two pastures. A modified version is called the Santa Rita Grazing System, sometimes used in the southwestern United States.

Additional fencing and moving of livestock are required. Every other year, livestock graze streambanks early when riparian areas and streambanks may be more susceptible to compaction and shear damage. Every other year grazing is late, when plant regrowth may be needed to protect streambanks from ice and flood scour. In Great Basin environments, however, there may not be any regrowth. A plus is that vegetation has the opportunity to store carbohydrates and set seed, at least every other year and often under good precipitation patterns, every year.

Better control of animal distribution, over season-long continuous is gained, resulting in more uniform use of herbaceous plants. As commonly used, each pasture gets grazed in the spring every other year when streambanks may be tender, and in the fall every year when vegetation is needed to get through coming flood periods. Regardless, this strategy under needed stocking rates is a great improvement over season-long continuous. However, the benefits are mainly to livestock.

Example of Deferred Rotation

<table>
<tr><th></th><th>PASTURE 1</th><th>PASTURE 2</th></tr>
<tr><td></td><td>A M J J A S O N</td><td>A M J J A S O N</td></tr>
<tr><td>1990 B</td><td>| " | ****** |</td><td>| ****** | " |</td></tr>
<tr><td>1991 A</td><td>| ******| |</td><td>| | ****** |</td></tr>
<tr><td>1992 B</td><td>| " | ****** |</td><td>| ****** | " |</td></tr>
<tr><td>1993 A</td><td>| ******| |</td><td>| | ****** |</td></tr>
<tr><td>1994 B</td><td>| " | ****** |</td><td>| ****** | " |</td></tr>
</table>

LEGEND

= REST

AMJJASON = MONTHS OF YEAR

****** = GRAZING PERIODS

" = SEED RIPE TIME

A = SPRING GRAZING

B = SUMMER-FALL GRAZING

A problem with the B (summer-fall grazing) pasture is that all mature growth is removed. Therefore, there is no winter protection for plants, feed for wildlife, or nesting cover for birds (i. e., chukars) the following spring. Ripe seed does get trampled into the soils. The treatment in the A pasture, providing new growth occurs, leaves little chance for seedlings to become established. The reason is there are few food reserves as none was restored.

Two Versions of Modified Santa Rita Grazing System[1]

	YEAR ONE			YEAR TWO			YEAR THREE		
PASTURE	Jun-Sep*	Oct-Jan	Feb-May	Jun-Sep*	Oct-Jan	Feb-May	Jun-Sep*	Oct-Jan	Feb-May
A	******					******			
B			******				******		
C				******					******

	YEAR ONE		YEAR TWO		YEAR THREE	
PASTURE	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr
A	******			******		
B		******			******	
C			******			******

LEGEND

* = Growing Season

☐ = Rest Treatment

****** = Grazing Treatment

Marlow and Pagacnik (1986) have used deferred rotation in Montana successfully. Marlow kept cattle in the uplands during June and July and moved to the riparian sites in late July where they grazed until October. Bank trampling was reduced by deferring grazing until after early August when soil moisture content had decreased in the streambanks. The success may have been in the 3-pasture design where he was able to limit utilization on the riparian sites to only 20 to 30 percent. Cattle were moved to the next pasture as soon as this level was met. This strategy was probably more of a deferred rotation with riparian preference pasture, than a straight deferred rotation. The BLM has successfully used this strategy in combination with herding in the Little Sandy Allotment in the Rock Springs District via the addition of herding to get the needed control in the riparian area.

For riparian benefits to occur, the stocking rate for this strategy is critical. It needs to meet the programmed intensity on the riparian system. The strategy also has to meet plant phenological development and climatic patterns. Success in uplands has been gained by adapting to calendar dates and checking on time of plant readiness for initial grazing.

To be successful in riverine-riparian habitats this strategy usually has to be combined with another strategy to gain control of animal distribution in riparian zones. This is usually always the case on mountain ranges with stringer meadows. Studies in the Blue Mountains of Eastern Oregon have demonstrated that deferred rotation is superior to season-long continuous grazing in terms of livestock performance. At the same time ungrazed pastures are provided for deer and elk. Big game animals, under this strategy, have ungrazed pastures where they can avoid livestock and not compete with livestock for forage.

Cool Season

Cool season grazing differs from winter grazing. Cool infers those seasons of the year when plants are growing but it is cooler than during the hotter summer months. It is often thought of as that period when the cool season vegetation growth begins and continues until vegetation growth peaks. The cool season period can vary from year to year, depending on climatic conditions.

Cool season grazing has been successful in Montana (Lew Meyers, pers. comm.), probably because it takes stress off plants during the summer when they are under high stress from heat and lack of soil moisture. Spring use normally results in better livestock distribution between the uplands and the riparian habitat. Riparian areas are usually wet or flooded and upland vegetation is more palatable. Caution must also be used in spring grazing as this is the period when soil moisture is highest in streambanks and they shear easily. Spring use provides more opportunity for plant regrowth and plant recovery. Plants will be in better condition to buffer and insulate the streambanks during flooding and winter freeze periods. Animals need to be removed in time to allow regrowth of plants needed to trap sediments used in the bank maintenance and building processes.

Cool season grazing shows much promise. It should, howver, be worked into some other grazing strategy for overall success. Livestock do have to feed somewhere during the complete year to survive. This means they have to graze somewhere during the hot season.

WINTER GRAZING IS SHOWING PROMISE IN SOME AREAS

Winter Grazing

Winter Grazing occurs only during winter conditions. To be successful, streambanks should be frozen and all riparian plants must be dormant. This is a period of little plant growth. At the same time it can be a period of heavy use on brushy species, especially if herbaceous forage is covered with snow.

Winter grazing can reduce a rancher's feed cost significantly, as winter forage availability eliminates the need to haul and distribute feed. In Oregon, this savings has amounted to as much as $30.00 per animal per year (Wayne Elmore, personal communication).

Rangelands must receive only light snow cover to allow livestock access to the forage.

Heavy grazing can eliminate the streambank vegetational mat needed to prevent soil erosion due to winter-spring floods or ice events. Vegetation can change from grasses to shrubby species, unless animal distribution is controlled.

Frozen streambanks are in their most resistant condition. They are less vulnerable to mechanical damage, minimizing streambank shear. Carbohydrate reserves have returned to the root system prior to grazing resulting in increased plant vigor. The major plus with winter grazing is that nonuse occurs every year during the growing season. Ripe seed is produced every year. Platts and Nelson (1984) in Otter Creek, Utah could find no effects on herbaceous vegetation and streambanks under winter grazing situations. Winter grazing can be the period of greatest use on browse species.

Stuttered Deferred Rotation

Problems and compatibility are the same for this strategy as for deferred rotation except the stuttering (two years in a row in the same pasture before rotating to the next pasture) can give brushy species and some grasses (Idaho Fescue) some relief. This relief can be beneficial to brushy species. They may be under-utilized during the early grazing sequence when cattle prefer more succulent vegetation, and better protected, after two years of fall rest, because livestock tend to take the recent year's growth.

This strategy does provide some nonuse during some critical streamflow and plant growth periods and thus may increase streambank plant cover. Over the 4-year period, however, each pasture is grazed over the complete growing and grazing season. This provides the possibility of streambank shear and winter-spring vegetation mat elimination.

This strategy is seldom successful on stream habitats unless combined with some other strategy to better control use in the riparian zone.

Herding

The herding method has many advantages. It has been well demonstrated with sheep and to a much lesser degree with cattle. Herding can be used to control the timing and amount of use in the riparian zone, thus achieving better utilization balance between upland and riparian forage. Some of the better managed allotments I have been on were in good condition because of herding.

In large land areas herding may be a necessity to gain proper animal distribution and forage use. Herding cattle into unused or under-utilized areas is a continual effort that never ends. Because cattle are creatures of habit and are attracted to low gradient areas with nearby waters, usually only herding or fences can control them. Herding also puts the livestock manager on the range where he or she can see problems developing and correct them. It also allows a constant reading on range use and trends in range condition.

HERDED SHEEP ARE USUALLY MUCH MORE GENTLE ON THE LANDS THAN CATTLE

The success of herding is dependent mainly on the rider's ability, but also to some extent on the terrain and cover. Today good riders are hard to find, mainly because livestock operators provide low pay, and most do not want their animals herded. The increasing cost of fencing and possibly some reduced livestock numbers so that rangelands can be rehabilitated may, in the future, make herding a realistic and economically sound method. Herding may be a successful method for bonding animals to upland areas if forage, water, and salt are all available there. This method has promise and should be used more and more on problem allotments.

Rest-Rotation with Seasonal Preference

This strategy is mainly used with sheep. The strategy can be very successful because riverine-riparian habitats can be grazed at times of least impact. Animals can be taken off riparian areas prior to any damage occurring. This strategy, although working well with sheep, can be hard on the cattle manager. The difficulty of herding cattle into the different pastures or areas to meet the seasonal requirements causes additional work. The strategy does allow all plants to be grazed under proper timing and utilization, giving them rest time to recover from past grazing use.

This strategy is excellent for sheep and should be used whenever possible. At this time it cannot be forced on cattle operators because of the intensive herding or pasture fencing requirements. However, because it does provide opportunity for the uplands to be managed under a compatible rest-rotation strategy, it still has considerable potential.

Riparian Pasture

This is one of the most successful strategies used to rehabilitate riparian systems. Because most allotments or pastures are too large for control of animal distribution and because livestock are attracted to moist riparian areas, separate riparian pastures are a way to gain control of animal distribution. The riparian pasture requires additional fencing, but the release of the uplands to a more feasible, less costly grazing strategy is often worth it. If grazing in the uplands is improperly done, however, off-site caused stress (e.g., sediment, high velocity overland flows) can still adversely impact the stream.

Placing the riverine-riparian system within a controlled unit allows all grazing to be programmed to meet the stream's ability to maintain itself in a productive condition, while still providing grazing opportunity. As the riparian vegetation regains its vigor and improved species composition, in many cases, the forage allotted to livestock can actually be increased. Riparian areas normally produce 3 to 4 times the forage that the same amount of upland area can produce. Regrowth of riparian vegetation usually can occur if animals are removed early enough. Streambanks then have full protection during winter icing and spring floods.

Costs of additional fencing and repetitive maintenance are higher than for most other strategies, such as season-long continuous grazing. Without control of animal stocking over the whole allotment, the use of the riparian pasture can cause an imbalance of animal distribution and forage in the remaining pastures during certain parts of the season, especially if the other pastures are overstocked.

For riparian pastures to be successful, they should contain as much of the stream as possible. Small stream sections within large upland pastures are hard to manage. In the design of the riparian pasture, the balancing of forage between upland and riparian areas is important. The amount of forage in the upland types should not limit proper distribution or utilization. For example the upland forage should be sufficient so that livestock will not be forced to the riparian areas to find sufficient feed. Forage balance between upland and riparian areas may change as the season and the kind of livestock changes. The influence of a cattle group's home range on grazing use will need careful analysis. Pastures may have to be larger than a herd's home range in less productive range types.

The use of riparian pastures offers alternatives to the elimination of livestock grazing and high costs of fencing the complete boundary of riparian areas. In designing these pastures one must consider the different types of riparian and upland vegetation, different sizes and shapes of pastures, and the different ratios of riparian forage to upland forage. When the fencing of narrow streamside corridors or the elimination of livestock are the only alternatives available for maintaining productive riparian and fishery habitats, the cost of special riparian pastures may not seem so exorbitant.

Seasonal Riparian Preference

This strategy has had little use to date, but will come on strong as more and more land managers and livestock owners move to better riparian management. Putting the riparian habitat into one or more preference pastures opens up the remainder of the allotment to more efficient and less costly grazing practices.

The value of this strategy is that the plants and streambanks can be grazed during that period when they are less vulnerable to damage. This may be during periods of plant dormancy or during periods when upland forage is more palatable. Like most strategies, the stocking rate, time, and duration of animals must fit the goals and objectives set for the riparian area.

This strategy does not have the time flexibility desired by many livestock managers. The pasture must be grazed during narrow time periods. Seasonal preference for the grazing or non-grazing of riparian systems is difficult to determine from year to year. There will be variation from year to year depending on climatic conditions. Therefore, managers must have a good data base or years of experience to make this work. Managers must also be on top of day-to-day rangeland conditions to enter the preference pasture at the correct time and get out of it when the desired utilization is reached.

Unless closely managed, streambanks can still receive shear stress, and late season grazing can reduce the vegetation mat needed to minimize flood erosion. Occasionally the timing of preference entrance may cause some overuse in the other pastures in the allotment, particularly if the allotment is overstocked. This strategy does require more fencing and animal movement than most other strategies.

Set-Back Pasture

The set-back pasture strategy has been used very successfully in some tough situations (Platts, Wagstaff, and Chaney 1989). A set-back pasture fits well into Kothmann's (1974) definition of a deferred rotation with selected rest. The set-back pasture strategy allows needed rest and grazing, or other prescriptions, to allow riverine-riparian objectives to be met. Even though this strategy can be quite successful, I would recommend that a riparian pasture be considered instead.

The corridor strategy requires proportionately more fencing for size of area protected than any other successful strategy. It should be used as a last resort. There are times when it is the only feasible alternative. When the corridor strategy is selected, the grazing of the riparian forage within the corridor is given up. Corridor pastures are usually too small and narrow to allow proper grazing management. However, the loss of forage is usually minimal. The initial cost of fencing and fence maintenance is high for the size of the area protected. Visual esthetics are impacted and recreational users react negatively to torn clothing and punctured waders. Also, the corridor strategy has been used to keep from addressing the real problems within the allotment.

On 365 miles of Oregon streams where riparian forage was identified, the riparian vegetation area comprised only 3.5 acres per mile. This equates to only 7 AUMs, or 100 cows for 2 days per mile. It is not known if livestock are stressed when they are denied grazing access to riparian areas. In areas where we have excluded them no differences in livestock health or behavior could be detected.

Corridor fencing has failed on most allotments or areas I have reviewed, mainly because allotment type fences were used to try and gain control of cattle movement. Corridor fencing usually works only when a corridor type fence is constructed. An allotment fence is only there so one knows where most of the animals are most of the time. They are not built for complete control of all animal numbers. A large cow and especially a small calf can go through an allotment-designed fence anytime they have a great desire to do so.

The corridor strategy does not treat deteriorated upland watershed conditions. If this is the case the symptoms are treated rather than the problem. The problem then never goes away. When corridor fences fail, years of rehabilitation can be lost in just a few days because of the extra large numbers of animals that concentrate on the lush vegetation.

This strategy has high up-front cost and continual high maintenance cost. Standard cost for two 30-meter-wide corridors is about $3,750 per stream kilometer, with $38 to $125 annual maintenance cost per stream kilometer per year (Platts and Wagstaff 1984). Many corridor fencing projects have gone down the tube before gaining the desired riparian rehabilitation because the maintenance cost was much higher and the need more frequent than what was anticipated and budgeted. The large distance of parallel fencing along the stream can also interfere with the upland distribution of livestock. Also, the livestock industry has constantly expressed opposition to this strategy.

Benefits can be immediate. The total rest, if you can get it, allows on-site riverine-riparian habitat to rehabilitate at full potential, providing the upland effects are under control. The isolation of the stream allows a simpler grazing strategy to be applied to the uplands and also allows full utilization of the upland forage. The cost of the simpler strategy in the uplands may pay for the cost of the riparian corridor. We must face the reality, however, that is not desirable or economically feasible to fence every streamside corridor. Therefore, grazing strategies must be developed that allow better control over intensity and timing of forage use in riparian areas, and forget about trying to fence the West.

Exclosures have been invaluable in enabling us to determine the site capability. From site capability information we can better determine resource allocation to livestock, wildlife and fisheries. There is a large variance between the rehabilitative potential of the different riverine-riparian complexes, and exclosures (corridors) can give us this type of information. This is the best use of the corridor strategy at this time.

Double Rest-Rotation

Any grazing strategy that allows a period of rest for a riverine-riparian habitat to rehabilitate has potential benefits. Success depends on the stream's capability to repair past damage and to maintain a vigorous riparian habitat. Double rest-rotation sets up long periods of rest. This strategy works better on riverine-riparian habitats than straight rest-rotation because the stream riparian habitat receives 2 years of back-to-back complete rest. This gives the stream twice the normal amount of time to recover from any previous degradation caused by grazing. Brushy species also have 2 years to set twig growth before being grazed again. An allotment in the Idaho Batholith grazed in this manner since 1965 showed steady improvement in both riparian and stream condition. This strategy will work on many riverine-riparian complexes as long as the one year of grazing in three is done in a manner to meet the requirements of a regular rest-rotation strategy.

Nonuse

Nonuse is a viable strategy that will need to be implemented to bring back some of the badly degraded riverine-riparian complexes that are difficult to rehabilitate. Nonuse, however, is a difficult strategy for the livestock manager to live with. It means he or she will have to find alternative sources of grazing if the same number of animals are to be carried in the operation. Also, the nonuse strategy does not fit well with lending institutions. For this strategy to work the livestock operator has to have some other alternative available that will keep the operation viable. This is one of the most important reasons for having allotments on both public and private lands that are not fully obligated.

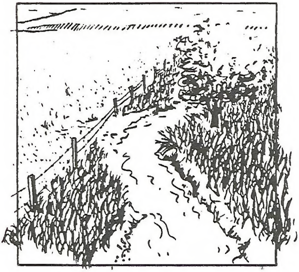
The Forest Service and BLM have made continuous serious mistakes in the past by having a policy that all rangelands must be grazed at all times. Whenever an allotment was given up by one permittee the agencies went to great extremes to see that the allotment was immediately taken up by another permittee. Even if permittees wanted to place their allotment into a nonuse category for a needed amount of years to gain necessary rehabilitation, on the third year the allotment was put up for permit to another permittee.

One of the most important things you can do in assisting the public agencies in rangeland management is to push for at least one or more allotments in nonuse in each district or area. Thus, there will be something to fall back on when other allotments get into trouble. As it is today, if one allotment gets into trouble, it stays in trouble, because the land manager has no options available for taking the stress off. Unlike leaving areas in an unlogged condition or saving timbered areas for another logging period, the grazing industry has seen to it that most all lands are grazed at capacity. This has taken away one of the most viable options to bring back western streams.

Rest

Although rest plays a role in some other grazing strategies as part of their treatment, it is another under-used strategy that has high potential to bring back Great Basin streams. Grazing in accordance with the physiological requirements of the vegetation involved is the quickest, surest, and most viable way to reduce current deterioration trends and initiate rangeland rehabilitation. Periodic rest is a key component in restoring vegetative vigor and productivity. The strategy does eliminate all forage use for at least a year, but the final pay-off may be worth it. Livestock managers could be hit hard during this period if they do not have other alternatives available. For this reason, total rest is not usually politically, socially, or economically acceptable. Regardless of this the benefits may outweigh the costs. Under periodic rest, riverine-riparian habitats move towards potential productivity, and resource products other than forage for livestock increase in value. These values usually outweigh the forage loss.

Rest allows degraded allotments to regain productivity in the shortest period of time so they can again be grazed under a better management strategy. Where riparian habitat condition is so poor that not much else will work, consider rest before initiating a good grazing management strategy. In areas needing riparian shrub and tree regeneration, rest may be the quickest and least costly way to restore seedling production and gain large trees and shrubs that can again function under grazing pressure.



PROCEDURES FOR WORKING WITH FEDERAL AGENCIES AND PROGRAMS

INTRODUCTION

I made many mistakes working with other disciplines and other agencies and paid the penalty time after time in my 30 years of public service. I can only advise you to consider what I write and not what I did. Through making these mistakes I have gained a better feel for how many of the important issues should be handled. Once in a while I had the patience to do something correctly. This and learning from my mistakes, is the basis for this advice.

Your achievement of NDOW's fish and wildlife goals will depend in a major part on your ability to sell and implement your ideas and programs to the land management agencies you deal with. This requires both technical and, most of all, interpersonal skills.

Technical Abilities

This Guidance Document can help you to be the best informed and the best prepared of any team members on any project you work on. You will have valuable input as a team member, one on one, or as a decision maker. To obtain your agency goals your fish and wildlife abilities must surpass those of the other specialists involved. Many times you can have greater influence on project outcome than the federal agency's own in-house specialists.

Some appropriate things to consider before the fact:

1. Have first-hand knowledge of the project or item under discussion. Even if you have been on site many times before, make sure that you have been there recently so you do not get tripped up on some recent changes.

2. If the issue is revising a grazing allotment management plan, ride the allotment with the land manager, range conservationist, and the permittee, if possible. Do this to establish personal and technical understanding of the problems and the people you will be working and sparring with. If no one will go with you, go alone, but "get dirty on the ground."

3. If the project is important to your wildlife-fisheries program and you aren't invited to attend field reviews, do not be bashful. Invite yourself. With your technical abilities they will soon wonder why they didn't invite you in the first place.

Once on the ID (interdisciplinary) or project team, show up at all meetings and do all assigned obligations. This workload will limit the time available for other projects but prioritized investment is usually worth it. Gain respect by being an experienced, dependable, and credible team member or adversary. You must earn respect.

DON'T EXPECT IMMEDIATE GOAL ATTAINMENT -- GIVE IT TIME

Interpersonal Relations

First, remember it's a two-way street. You have to give to receive. When you are one-on-one or in a group, constantly ask yourself, "Am I approaching them in the manner I would like them to approach me?" Because wildlife and fisheries management is mainly people management, this truism can never be forgotten. Your ability to sell your wildlife-fisheries ideas or programs depends a lot on how your colleagues believe it will fit into their people management. People management can turn into political management. If this happens, different approaches must then be taken as discussed later.

Your Department can use all the goodwill it can achieve. Build this goodwill at every opportunity. Remember your objective is not to save the world at any cost. You work for a service agency, and you must provide service to gain this goodwill. Drop by the offices of the federal employees you must work with. Make these visits short but productive. Remember, they make more money than you do working less hours, so don't waste any of your hours. Your job is to make these hours pay off for fish and wildlife. Ask your counterparts to visit some of the work you are doing, both the good and the bad. They will feel better when they find out other people are making mistakes too. Sharing your projects and building goodwill will pay off handsomely in the future.

WORKING WITH PEOPLE IS LIKE BANKING -- MAKE STEADY DEPOSITS OF GOODWILL KNOWING THAT WITHDRAWALS WILL BE NEEDED IN THE FUTURE

Develop a personal understanding of the way your federal counterparts work, their strengths and weaknesses. Identify the person who will make the final decision. You must be effective in counseling the decision maker. Seldom will you be allowed to work directly with the real decision maker who stays behind the scenes -- this will not be allowed, and as discussed in sections on the respective agencies, it is often their ace in the hole to be played at the right time.

Whether your colleague across the table or on the horse in front of you is an adversary or a proponent, get into his or her mind. There is nothing that leads to success more than being able to think 15 minutes ahead of the person you are working with. Understanding people's thought processes is an art, not a science, and comes only with experience. Find out little things such as whether this person needs your thinking in the form of an official memo or whether it be more effective given around a campfire.

WHEN IN DOUBT AND UNDER PRESSURE, PLAY IT DOWN THE LINE WITH INTEGRITY

Look for common personal interests as well as professional ones. Your federal co-workers are experts at this with their guided trips down the Middle Fork Salmon River, horseback trips through the Sierras and back pack trips into the head of the Yellowstone. Your recommending a spot for a son to harvest his first deer or where the daughter can catch a photogenic fish will always be remembered. One biologist successfully proposed or actually modified dozens of projects in the favor of fish and wildlife by establishing a personal credibility with district rangers. His main sales technique was to hunt and fish with them in habitats similar to those he was trying to maintain within their own management areas.

Don't lose your professional stature by being clever. Be consistent and honest to create an atmosphere of trust. Never surprise your counterpart. I used to purposely surprise people I didn't like to work with. I can never remember coming out ahead with this approach. I had a few minutes of happiness by winning some small battles but frequently lost the wars, which was more agonizing.

ONCE YOU HAVE IDENTIFIED PEOPLES WEAKNESSES, IGNORE THEM; ONCE YOU HAVE IDENTIFIED PEOPLES STRENGTHS, FULLY UTILIZE THEM

If you disagree with your working counterpart, don't use a memo or a phone call to express it. Take time to do it in person so the reasons can be readily discussed. Go to a third party for advice if necessary. If you have to disagree, do so openly. Whatever the final outcome, thank the person for his or her time. This is the professional thing to do.

Never go over your counterpart's head, except as a last resort. Remember that if you do, this person can seldom be counted upon as an ally on tomorrow's wildlife-fisheries opportunity. If you do go over your colleague's head, try to have your supervisor do it, hopefully in a tactful way. You may be able to salvage some future working relationships.

Never underrate your counterpart; to do so means to get badly mangled if things get rough. People can act and look dumb or naive, but imagine how you will look after this caliber of person has out-maneuvered you. Overrating your opponent will be safer in the beginning of any effort and it's also flattering to the person being overrated.

FRIENDS COME AND FRIENDS GO,
BUT ENEMIES ACCUMULATE

The Art of Negotiating

Before beginning a cooperative project with a federal land management agency, identify your Department's goals. Then list your personal goal in this venture so you will be able to measure your success of accomplishment. The fad nowadays is a "win-win" approach to management. Both sides may not win but it sure helps if your colleague thinks he is winning. Find out what your agency counterpart wants out of this negotiating maneuver and then find out a way to get it for him or her -- providing it is not too detrimental to your cause. His immediate project may not be in line with your top priority, but when it comes time to play your ace you will have a supporter.

Earlier I stated how important it is to always think 15 minutes ahead of your counterpart. Do this by knowing beforehand what your resource needs are and what the pathway is to get there. But -- also have a list of descending compromises and know where the bottom line is that you will no longer negotiate below on this given day. Whatever you do, don't let your compromise position be known until you have to lay it on the table. If you are out in front in the thinking arena, you will know his compromise limit before he knows yours. If you cannot live with his bottom line, end the negotiating session prior to the decision stage so you will all live to battle another day. Time heals many things and it's amazing how time builds understanding and coming together.

Negotiate in person. A very politically successful northern Nevada rancher, confides that it's always harder for the opposition to say no when they are sitting across the table, and especially if this table is standing in your house. Negotiate in person and do your own negotiating.

Three key elements for successful negotiating are knowledge, power, and time. If you have more knowledge than your negotiating partner, you will have the advantage. Power is having the legal and financial backing behind you. If you are speaking for a threatened and endangered species or species of concern, you have power. If your Department is supplying part or all of the money to complete a cooperative project, you have power. You often have more power than your federal counterpart as you can often speak for your regional supervisor or your director, especially when your colleague can only speak for him or herself. Put time on your side. This is difficult to do in wildlife-fisheries management when every day is so important. Whoever has to meet the first deadline in making a decision is usually at a disadvantage. If you have a deadline and the opposition won't move, then you must be careful how the decision making is done.

Summary

There are two basic questions you should constantly be asking your federal counterpart and they are (1) What can I do to make your work more productive? and especially, (2) What do I do that hinders your ability to do your job? You will be amazed at the answers but they sure give you something to build on in the future to get your way in building a productive program.

Recognize all fish and wildlife accomplishments by your counterparts, and they will be greatly appreciative. Theirs is often a lonely, frustrating business, where they have to buck heavy pressures from the other resource advocates. Always remember that many good people have ruined their careers supporting sound wildlife-fisheries management, especially when it interfered with the harvest of other resources the agency is hung up on. Be very careful you do not hurt another person's career. A pat on the back or a sincere thank you can make it a little more encouraging for this person to take on the other special interest groups who are standing in the way of good wildlife-fisheries management. Make sure that this good work is known to the right people and don't unnecessarily advertise it to the wrong people.

Never get lazy, careless, or complacent as seldom in the wildlife-fisheries field is today's victory permanent. Today's forging ahead will be set back by tomorrow's wildfire, the coming drought or flood, the weakening of agency initiative, decreased funding, increases in stocking levels, opening up new areas to logging, and sudden changes in political direction. There will always be another day, another challenge, and another breakthrough. This is why you have job security. After contemplating all these things, your moral obligation is to make sure you leave things much better than you found them.

WORKING WITH THE FOREST SERVICE

Structural Organization

The Forest Service is a decentralized, militaristic, resource management agency organized along the structure set out by its founder, Gifford Pinchot in 1906. Gifford Pinchot's philosophy of managing the lands to, "... provide the greatest good for the greatest number...," is as sound today as it was then. This philosophy fits well with the needs of wildlife and fisheries. It was when Pinchot's philosophy was distorted to the best use for a *few* of the people that wildlife and fisheries suffered.

The Forest Service is headed by a "Chief" who has always come up from the ranks, unlike in the BLM which almost always gets a political appointee. This has helped the Forest Service develop a strong agency with good leadership ability. Still the Chief's Office, at the Washington D.C. level, is sensitive to current administrative policies and political appointments at the Secretary and Under Secretary levels. The agency is very sensitive to budget procedures and allocations. The Washington level of the Forest Service is most effectively influenced by lobbyists for major forest users, environmental groups, timber interests, and livestock grazers.

The Forest Service has 10 regions headed by a Regional Forester. The Intermountain Region (R-4) administers the Humboldt and Toiyabe National Forest in Nevada. The Regional Forester approves Forest Plans, large land exchanges, introduction of new or different wildlife and fish species, and other projects beyond the authority of Forest Supervisors. The Regional Forester and staff *do not* manage lands or their resources. They administer the people, money, and policies that control resource use at lower levels. The Region is very sensitive to Washington Office influence, any congressional inquiries received, your Governor's and your Director's concerns, and state lobby groups. An example of effective influence being applied to the Region would be a phone call to the Deputy Regional Forester for Resources from an attorney representing either the state wildlife federation or the Nevada Cattlemen's Association.

The Forest Service is an agency in turmoil. There is strong vocal dissatisfaction among the personnel. The turmoil may be brutal at the present time, but in the long run, because the Forest Service is a strong organization, it will improve greatly. The Forest Service is much like the FBI was under J.E. Hoover -- structured almost in concrete. This the reason that the present mutiny by Forest Supervisors is so unheard of. If the Forest Supervisors hang tough and get the changes they are after, the Forest Service will again be the best-managed and most productive agency in the federal government.

It's interesting that the Forest Service is filled with top people with excellent land ethics at the middle layers (Forest Supervisors), and the BLM is blocked because its middle level is filled with District Managers who care little about land stewardship. There is a great lesson to be learned here on social-political dynamics, but I'm not smart enough to figure it out.

You will be able to work much better with the Forest Service in the future if you understand the direction in which the Forest Supervisors are trying to move the agency. The following is a summary of comments from two open letters to the Chief in 1989:

> *[Forest Supervisors, Regions 1,2,3, and 4*
> *Combined Letter to Chief (1989)]:*
>
> The emphasis of national forest programs does not reflect the land stewardship values embodied in forest plans, Forest Service employees and the public. The administration's program and congressional annual appropriations still emphasize commodity programs.
>
> Encourage forest supervisors and regional foresters to increase grass-roots support through the use of public work groups to help us make "better" decisions.
>
> Our timber program has been 35 percent of the National Forest System budget for the last 20 years while recreation, fish, wildlife, and soil and water have been 2 to 3 percent each.
>
> Only 30 percent of the annual budget ever gets to the ranger district.
>
> Employees and the public are dissatisfied with the quality of today's resource management. They strongly support our mission statement, but they do not believe we are living it.
>
> Many members of the public and many of our employees no longer view us as leaders in environmental conservation. A large

> percentage of the western rangelands are in poor condition after 80 years of management.
>
> We continue to maintain strong relationships with commodity groups, often at the expense of developing and improving relationships with other groups.
>
> We need internal reform to do our jobs right.

[Open Letter to the Chief from Region One Supervisors (1989)]:

> Many people, internally as well as externally, believe the current emphasis on national forest programs does not reflect the land stewardship values embodied in our forest plans. Congressional emphasis and our traditional methods and practices continue to focus on commodity resources.
>
> We are not meeting the quality of land management expectations of our public and our employees.
>
> We are worried that if we don't make some major changes as an agency, our mission statement will never move from rhetoric to reality.
>
> There is a growing concern that we have become "an organization out of control."
>
> We are spread too thin. It is time that we start dealing with our internal problems, before we crack apart at the seams.

Forest Supervisors administer a national forest and are responsible for all decisions made on the forest. Forest Supervisors approve by their signature reintroductions of wildlife, grazing allotment management plans, large project NEPA documents, and other items or projects not approvable by District Rangers. The Supervisor's staff, with whom you will often work, provides guidance to the Supervisor. They do not manage lands or make decisions. Wildlife and fisheries within both the Humboldt and Toiyabe National Forests are grouped with range, soil, water, and air under one staff officer. The staff officer typically has one or more specialists in each of these fields reporting to him and providing technical support to the ranger districts. An exception to this rule is that the Humboldt Forest has seldom had a fisheries biologist on staff. Forest Supervisors are sensitive to Regional Office (called the RO) concerns, budgetary opportunities to accomplish Forest objectives, (especially with other people's money), and county-level government and state lobby groups. A common example of an effective wildlife influence on a Forest Supervisor is the Regional Director meeting with him informally.

The Ranger District is the ground level, action unit of the Forest Service. Here is where the plow meets the soil. Regardless of higher direction, this level has great discretion to implement or postpone resource activities that would benefit or degrade wildlife-fisheries. This is the most fertile Forest Service level for you to work with and cultivate.

The District Ranger is the "line officer" who makes the district decisions. His staff only recommends decisions to him or her. Depending on his or her management style and interests, the ranger may or may not understand wildlife conditions on the district. The approved Forest Service mobility policy is to leave rangers in place no more than 7 years. This is done so they cannot build constituencies for a power base. Thus, you will usually be working with a decision maker that does not know the area, and especially the wildlife resource, very well. You may feel that this is a disadvantage but it is a lot better than having the ranger become dominated by one special interest group.

There has been a concentrated push to move more women into ranger positions for better balance. This has been very beneficial for the Forest Service as their rapid advancement has brought more contemporary resource management philosophies to Forest Service decision making. Most women have an excellent grasp of the wide array of resources on the district and are not so inclined to concentrate on only a couple dominant resources.

Ranger district specialists may include a wildlife or fisheries biologist. Often a person is assigned both resources. This can be a detriment to the resource they are weakest in. Sometimes you will find a range conservationist in charge of wildlife and fisheries. This is the worst situation.

You will find that when a district first brings on a wildlife or fisheries biologist, they are very talented and full of energy. The strongest suit in the Forest Service today is the wonderful cadre of young biologists the Forest Service has hired. This is paying great dividends for wildlife and fisheries. One thing you have to watch for, however, is the District Ranger who believes that wildlife or fisheries can be handled by anyone, and especially someone who has not proven him or herself able to manage anything else.

In the past it was common to take those people who were not making the grade, and make them fisheries and wildlife managers. This is no longer the case and the Forest Service is on its way to having the top cadre of fisheries and wildlife biologists in the world. They have even broken away from lumping fisheries under wildlife to try and downgrade it. Fisheries has gained needed stature and is now its own profession.

While there is a legal mandate for multiple use, wildlife and fisheries have historically taken a subordinate position to the commodity uses within the Forest Service. Because the Forest Service is such a "set" organization, it has greatly resisted changing this tradition. In Nevada, livestock grazing users have been and still are the most powerful grass roots lobby at the District level. This is why you must learn to work effectively with these people.

Ranchers are very good at interpersonal relations and you can take lessons from them. They always have a friendly wave when passing on the road. They are a source of lambs and pet ponies for a ranger's family, as well as a good home-cooked meal whenever the ranch is visited. They are great at lending a sympathetic ear to the ranger's problems with his bureaucratic supervisors who are keeping him from getting his job done or an advancement. I have sat in on many of these therapeutic sessions. The rancher is a master lobbyist, having learned it well from his father. You do not have this wealth of hand-me-down experience but you can still learn a lot by watching them operate. Don't begrudge the rancher for having this great knack; there is nothing much more important than interpersonal relationships.

We have discussed the three levels of the Forest Service where all decisions affecting the wildlife-fisheries resources are made. It is important to know at which level you should be working and at which level you try and steer people above and below you into operating. As I mentioned previously, the Forest Service has definite levels. This is why it is so important that the Director conducts business *only* with the Regional Forester. Even at this level there is still have one higher level (the Washington Office) they can go to for decision making. Almost always the Forest Supervisor will try and work directly with the Director. This means they always have an ace to play if things don't go right by having the Regional Office step in and reverse a decision made between the Director and the Supervisor. Again the Director needs to work with the Regional Forester, the Regional Supervisors with their respective Forest Supervisors, and the Regional Management Biologist with the District Rangers. This working relationship makes decision-making much more effective and lasting.

Forest Service Philosophy and Reality

Your agency has the responsibility to manage the fish and wildlife resources. The Forest Service has the responsibility to manage the habitat, so responsibilities overlap. The Forest Plan is the guiding document for all land management under a multiple use mandate. You and your agency usually consider the other resources, such as grazing and mining, only in the context that affects your wildlife-fisheries resource. This creates a line of thinking that is envied by your forest counterparts who must serve under a multiple use charter. They are faced with a Gordian knot of selecting those actions which will, "... serve the greatest good for the greatest number." This must be done with conflicting uses that have powerful in- and out-agency supporters. Fisheries-wildlife resources do extremely well under the multiple use mandate of the greatest good for the greatest number of people. Most of the publics you work for fish and hunt. Almost everyone has a kind place in their heart for wildlife and to a lesser extent, fisheries. If Forest Service lands were managed for the greatest good for the greatest number, most problems would be eliminated. In reality we all know that this is not the present situation in the Forest Service, but the trend is improving.

TO NOT BE ABLE TO WORK WITHIN THE REAL WORLD LEADS TO FAILURE

What Forest Service Line Officers Consider

Your Forest Service co-workers, like you, operate in a bureaucratic environment that rewards first and foremost those who succeed in furthering organizational goals. This is political reality that must be faced and worked under.

The Forest Service is very sensitive to external pressures. It's continually surprising to me how sensitive it is to internal pressures, especially those internal pressures that have a powerful outside power base. This makes change difficult even though the top of the agency has been clamoring for change. This sensitivity to real and potential pressures frustrates those trying to convince the agency to take a course of action for the benefit of wildlife and fisheries.

Agency decision makers often appear to over-study and delay actions that demand obvious solutions, even according to their own agency directions. These Forest Service decision makers have made their careers by taking actions that further the agency's standing and avoiding actions that detract from it. This is not an easy course to travel. They have all seen more talented peers' careers suddenly terminated for taking other courses or making decisions that run counter to the agency image. That is why they fully explore each decision and action. You must accept this fact.

The Forest Service, like any other agency, must have public and political support. It needs the support of the bulk of the public in order to survive. Forest Service line officers have learned that it is easier to say "no" or defer a decision than to immediately approve a course of action that may alienate a powerful interest group. Wildlife and fisheries values often run counter to the needs of these power bases. Therefore, you will need public support in your work and actions.

Like you, most Forest Service personnel want to leave the resources they manage in better shape than they found them. They well know that riverine-riparian systems on Forest Service lands are in poor condition and badly in need of better management. They are quite receptive to positive wildlife and fishery proposals that improve this habitat and further the agency's mission. Tailor your proposals to fit this situation. Make your project proposals directly to the District Ranger. They should be bold and likely to play well in the local media to gain his or her backing. Develop projects in partnership with the District Ranger. Make use of the current Forest Service "Partnerships" and "Challenge Grants." They benefit both your agency's and the Forest Service's image and public relations needs. They provide highly visible, usually noncontroversial projects, paid for by other people's money, that immediately endear your agency to an outside support group. Provide such projects and you will be highly thought of by your Forest Service co-workers.

"THE FOREST SERVICE RIPARIAN PROGRAM AT THE FIELD LEVEL IS VERY UNEVEN IN ITS IMPLEMENTATION AND HAS NOT BEEN GUIDED BY STRONG NATIONAL DIRECTION"

-PAUL BROUHA - GAO HEARINGS

Riparian Policy

The Forest Service is one of the leading public agencies in the preliminary move towards responsible riparian management. Its extensive management branches, and to a much lesser extent its research branch are spending millions of dollars to improve riparian habitats impacted by livestock grazing. The agency has been driven to this massive effort of undoing a half century of poor riparian management mainly by internal direction. These forces for change exist from the highest levels in the Chief's office on down.

The Chief of the Forest Service stated the agency's riparian policy for the 1980's in a speech delivered to the Western Division of the American Fisheries Society (Peterson 1983). He stated that the Forest Service goal is to prevent and correct situations before they require extensive rehabilitation. High priority would be given to restoration of riparian areas. Riparian habitats were to be managed under the principles of multiple use, with special emphasis on fish and wildlife resources.

THE FOREST SERVICE'S "CHANGE ON THE RANGE" HAS FINALLY RECOGNIZED THAT RANGE MANAGEMENT GOES BEYOND ANIMAL UNIT MONTHS

The present head of the Forest Service's division of range management recently (1989) told members of the National Public Lands Council that Forest Service-permitted livestock grazing will be allowed *only* in those areas where it is *cost-effective*. He further stated that grazing will be eliminated from areas that will be classified as unsuited for grazing. This alone could greatly benefit Nevada's rangelands.

The Forest Service expects increased pressures to further restrict grazing where it may affect riparian areas, threatened and endangered plants or animals, and wilderness values. Because grazing is such a strong Forest Service tradition, even under the present subsidy system, the agency has its work cut out for it.

There are many traditional grazing managers within the Forest Service. Retirement and, to a lesser degree, a change of attitude is rapidly reducing tradition. Also, at the grass roots of the rural West, the Forest Service has traditionally needed and received support from its dependent commodity users, such as livestock operators. This support will still be there but at a much less effective level. No longer can this group get a District Ranger moved at their whim. Thus, there will be more and better cooperation from them in the future. Although Forest Service management has occasionally resisted riparian management improvements, support in recent years has generally improved (GAO 1988). The GAO found upper management levels usually supported field-level decisions that required reductions in grazing AUM's to maintain or improve riparian areas.

In 1987 Region 4 approved its 10-year Region Riparian Action Program for guidance during the coming decade. Proposed actions included:

1. Create a regional management training program.
2. Include riparian performance in annual report cards of all line officers.
3. Administer an awards program for riparian accomplishments.
4. Increase information-education.
5. Increase regional direction for coordinated riparian management.
6. Each forest and district will set up a riparian demonstration area.
7. Every grazing allotment management plan will be modified by 1992 to address riparian needs.

Item 7 is one to focus on when working with district personnel. They must be held accountable for their own guidelines.

Legal Requirements

The Forest Service must abide by the mandates delivered in the National Environmental Policy Act (Environmental Impact Statements, Environmental Analyses, Categorical Exclusions), The National Forest Management Act (Forest Plans), the Multiple Use Act, and others. Their projects must abide by state laws and regulations. Please refer to the section on Legal Mandates (p. I-38) to determine other requirements this agency works under.

Another item to remember is that all Forest Service actions can be appealed. You will seldom deal in appeals, but you should understand how they can affect your management program. The Wilderness Society has published a booklet on "How to Appeal a Forest Plan." Anyone can appeal any decision for any reason. Only valid appeals will remand a project back to the planning stage for modification. The Forest Service has spent millions of dollars resolving administrative appeals and in court defense of unresolved appeals. In face of an appeal, Forest Service line officers will do their very best to negotiate an agreeable settlement to keep it from going to the courts for decision. Use negotiation to effectively move the agency towards better riparian management, and in turn better fishery management.

Multiple Use Act

Forest Officers must abide by various legal mandates but their primary guiding act is the Multiple Use and Sustained-Yield Act (MU-SY). This act requires that all renewable resources such as grazing be managed in concert with all the other resources to best meet the needs of all the people with no impairment of the productivity of the land.

Between 1960 and 1970 the concept of "multiple use" was managed much as the Forest Service wanted it. Although it was a good act with good intentions, often it was vague enough that single use management resulted. In 1970 the National Environmental Policy Act required an examination of the environmental consequences of how "multiple use" was being implemented and a whole new ball game began which was slowed down considerably but played with the same old players. Out of this "marriage of the acts" comes much better riverine-riparian management.

MULTIPLE USE LIES IN THE EYE OF THE BEHOLDER -- IT HAS NOT BEEN ADEQUATELY DEFINED EVEN THOUGH REQUIRED BY LAW

Working with the NEPA Process

The National Environmental PolicyAct process requires federal agencies to fully disclose the environmental impacts of their projects. NEPA requirements are met by using one of three documents -- Environmental Impact Statements (EIS's), Environmental Assessments (EA's), and Categorical Exclusions (CE's). These disclosure documents serve as a record of the procedural decision-making steps required by law. Only the EIS is mentioned in NEPA. The other two have evolved through necessity as NEPA evolved with case law from disagreements between the agency and its constituents. Qualified, non-Forest Service personnel can serve on interdisciplinary teams for a federal agency's EAs and CEs. Only Forest Service employees may serve on EIS interdisciplinary teams.

Procedural requirements by NEPA are interdisciplinary input, public scoping of issues, accuracy of data, and notification of interested parties.

Environmental Impact Statements

EISs are the most lengthy NEPA disclosure documents. They typically exceed several hundred pages. They are required where a project "will significantly affect the human environment." This significance threshold can be reduced to an EA level analysis if there is sufficient project mitigation. The question of whether to prepare an EIS is initially left to the discretion of the federal agency. Both negotiation with interested parties and the courts may alter this initial decision. Environmental Impact Statements may either address specific actions or be programmatic umbrella documents covering a large number of planned actions. Programmatic EIS's accompany Forest Plans. Programmatic EIS's don't disclose site-specific environmental effects, project alternatives, or connected actions.

Environmental Analyses

An Environmental Analysis (EA) is the workhorse Forest Service document. It is used for wildlife reintroductions, timber sales, allotment management plans, road construction projects, etc. The Council on Environmental Quality has recommended that EA's be 10-15 pages in length. This guideline has not been upheld in court. Depending on the complexity of the project, the EA is approved by the District Ranger, the Forest Supervisor, or the Regional Forester.

Categorical Exclusions

In an effort to increase productivity, the Forest Service is encouraging greater use of Categorical Exclusions (CE's). Use of these generally 1- to 3-page documents stems from Council on Environmental Quality regulations requiring federal agencies to define categories of actions not requiring an EIS or EA (40 CFR 1500.5, 1508.4). Categorical Exclusions are an effective way to meet NEPA's requirement with minimal paper work. CE's are generally approved by the District Ranger and document procedural steps for wildlife guzzlers, osprey nest platforms, livestock troughs, etc.

A current and a very understandable fear in the Intermountain Region is that almost all old allotment management plans may not entirely meet NEPA and/or FLPMA requirements. It may therefore be inappropriate to issue a grazing permit without the appropriate NEPA document. This will further entangle the Forest Service with paper work.

Endangered Species Act

This Act requires all federal agencies to undertake affirmative programs to conserve endangered and threatened fish and wildlife. It most importantly forbids agency action that either jeopardizes the continued existence of protected species, or results in the destruction or modification of their critical habitats. This Act has strong application in many parts of Nevada because of the numbers of endangered species, including plant species.

Forest and Rangeland Renewable Resources Planning Act

This Act, as amended by the National Forest Management Act, requires the Forest Service to assess and monitor its actions. As a part of the assessment, the service develops and maintains on a continuing basis a comprehensive and appropriately detailed inventory of all national forest system lands and renewable resources. This inventory shall be kept current and will be coordinated with state governments. The Act also calls for the development and maintenance of Forest Plans. In summary it creates a duty to monitor and consider all resource impacts in an integrated fashion.

Forest Plans

Forest Plans are a contract between the Forest Service and the American public to manage public lands in a manner dictated within the contract. Plan implementation must abide not only by what is in the plan, but with all state laws and regulations. Once the plans are out and the public begins to understand what the contracts with them mean, the management of the National Forest will never be the same. Never again will the Forest Service manage the lands as they alone deem fit. The public will make sure this does not happen, and you also must make sure this never happens again.

Because of the long-standing economic relationship the livestock industry has had with the Forest Service, they have a thorough understanding of the legal, political, and bureaucratic processes the Forest Service must go through to develop and implement the Forest Plan. No longer can you turn your back on these documents as they mean too much to the wildlife-fisheries resource. The livestock industry is represented by skilled and well qualified individuals that handle their planning and implementation inputs. You must also operate at this level, because often you are the only wildlife-fishery advocate. You will find it a lonely and frustrating world if you are unskilled in these matters and your counterparts are ahead of you in understanding.

Use the Forest Plan to insure fishery-wildlife habitat is managed as called for in the plan. Hopefully, you were on top of things and entered wildlife-fishery needs into the plan. If not, you must be prepared to modify the Forest Plan at its 5-year review or 10- to 15-year update period. The plan identifies long-term objectives, guidelines, and standards to protect the unique values of riverine-riparian areas.

Management direction for riverine-riparian areas derives from the Forest Plan and other state and federal legislation. The Forest Plan calls for actions that maintain or enhance wildlife-fishery values and gives *preferential* consideration to riparian-dependent species. The plan prohibits management practices that have serious and adverse effects on water conditions and fish habitat. Models and guides in this document should be used to determine if temperature changes are or *have* taken place.

ALL THE GOOD PLANNING IN THE WORLD WILL NOT BENEFIT FISH AND GAME UNLESS PROPERLY EXECUTED

All sub-plans must be consistent with the Forest Plan. Check problem Allotment Management Plans (see below), or areas that are having grazing problems, to see if they abide by Forest Plan direction.

The Forest Plan must be monitored. The Ninth Circuit U. S. Court of Appeals has twice ruled that a federal agency has the continuing duty to gather and evaluate new information relevant to environmental impacts of its actions. You cannot only input during the development of the monitoring plan but also during monitoring. Interpretation of monitoring data should come to you automatically, -- if not, take steps to see that it does. Then keep up on data interpretation that indicates needed management changes. *Always* make sure the plan is being followed.

Allotment Management Plans

Another excellent tool for wildlife-fisheries management is the Allotment Management Plan (AMP). In summary, AMP development covers four major points:

1. The Forest Service manual requires a plan for all grazing areas.
2. AMP's must be consistent with the Forest Land Management Plan and consider resources other than grazing.
3. The AMP must set "proper use criteria" for *each unit of each grazing allotment*. Once within the plan, when livestock exceed this level they *must* be moved out of the area.
4. A key statement in the Forest Service Manual is, *"Where range improvements are not cost-effective and management alone will not solve resource problems, aggressive livestock adjustment action must be taken* "(FSM 2203.1 (R4).

A current fear in the Forest Service is that almost all old Allotment Mangement Plans may not meet NEPA or FLPMA requirements. It may then be illegal to issue a grazing permit without the appropriate NEPA document. An AMP requires one of these NEPA documents:

1. An EIS if there is significant effect on the environment.
2. A finding of no significant impact.
3. A Categorical Exclusion.

Forest Supervisors approve and modify AMP's to control lower-level administrators who let them slide through from year to year.

A key point in Forest Service range management is the requirement that wildlife management indicator species and their habitat requirements be identified and evaluated as an integral part of the range analysis and allotment planning process. The Forest Service Range Manual (2200) and Handbook (FSH 2209), as required by Section 8 of PRIA, require that permittees be involved in the range analysis and planning processes. Wildlife or fisheries expertise is required to meet interdisciplinary requirements. In practice you may have to invite yourself in at the proper time. NEPA scoping requires that interested and affected publics (such as *you*) be given the opportunity for mutual appraisal of the range allotments and other projects during the analysis process. This is your "in" for your input into analysis and decision making. Remember that AMP's should carry into effect all of the fact-finding and planning that has gone on before. This means they should have been preceded by good inventories, Environmental Impact Statements if needed, and proper land use plans. The Allotment Management Plan is commonly thought of as the activity plan for livestock grazing. It should be much more than this.

Checklist for Reviewing an AMP

•

Do objectives include your resource needs?

•

Can the success or failure of these objectives be measured?

•

Was a reasonable time frame for accomplishment designated?

•

Were problems identified?

•

Are the solutions really feasible and capable of accomplishment?

•

Do monitoring plans meet the objectives?

•

Is the AMP in compliance with laws and regulations?

•

How do the Habitat Management Plan and this AMP come together?

•

Does the plan identify the impacts of grazing on wildlife-fisheries resources?

•

In drought or other unusual years, determine if livestock are taken off the riverine-riparian areas in time to meet the AMP objectives. During the drought years of 1987 and 1988, the Forest Service did not get on top of needed changes in livestock grazing. AMP's call for proper management practices at all times. You can make sure that needed changes or practices are not ignored at key times. Once the proper use criteria is exceeded in any allotment, livestock must then be removed.

STUDY AND DIGEST THE ALLOTMENT PLANS AND THUS MAKE THEM ONE OF YOUR MOST EFFECTIVE TOOLS FOR GOOD RIVERINE-RIPARIAN MANAGEMENT

You should take the time to understand an Allotment Management Plan better than your Forest Service counterparts. It's surprising how little time this takes. The AMP prescribes specific range condition and trend monitoring. This is why I always ask the local range conservationist what the range condition and trend is on a certain area of land and by what process did they get to their answers. Usually they cannot show you a valid way that they came up with trend. Condition is usually given to you through the eyes of a cow, and not necessarily the needs of the other resources. Most AMP's have resulted from many years of on-the-ground negotiations with the range conservationist and the grazing permittee. Each AMP should be checked to make sure that it contains a riparian-area inventory and management section. This section must include the monitoring methods and schedules necessary to assess impacts on riverine-riparian habitats. In the past, most AMP's were single-use oriented.

Forest Service Manuals and Handbooks

EACH AMP SHOULD BE CHECKED TO MAKE SURE THAT IT CONTAINS A RIPARIAN-AREA INVENTORY AND MANAGEMENT SECTION

To guide his fledgling Forest Service's resource management activities in 1906, Gifford Pinchot put it all in a pocket-sized "Use Book" less than three-quarters of an inch thick. The Forest Service manual and handbook system now occupies over 20 feet of shelf space! The manual and handbook provide the rules within which Forest Service officials are authorized to manage. You should have a passing knowledge of what is in these directives. They provide guidance on everything from building fences for passing antelope to outlining how grazing receipts can be spent for wildlife or fisheries habitat improvements.

The manual and handbooks are coded by number. Stating, "This project comes under 2600" means it comes under the guidance-direction for managing fish and wildlife.

Common manual and handbook resource sections you need to be vaguely familiar with as they relate to fisheries and wildlife are:

2100	Environmental Management (covers water, air, pesticides and energy)	
2200	Range (covers allotments, permits, improvements, and wild horses)	
2300	Recreation (covers wilderness, off-road vehicles, and archaeology)	
2400	Timber (covers all phases of timber management)	
2520	**Riparian Management**	
2600	**Wildlife and Fish**	
	2610	Cooperative relations
	2620	Planning
	2630	Habitat
	2640	Stocking and Harvesting
	2650	Control
	2660	Administration
	2670	Threatened and Endangered Species
	2680	Classified Area Habitat Management
2700	Land Uses (covers permits and ROW'S)	
2800	Mining	
5100	Fire Management	

The riparian standards in 2520 are specific to several land management functions, including watershed management, wildlife, fish, and sensitive plant habitat management. The manual states that preferential consideration will be given to riparian dependent resources when conflicts among land use activities occur. This should be kept in mind constantly in your input into their riparian management.

Forest Service Handbooks

Forest Service handbooks guide everyday planning and management. Handbooks of interest to wildlife and fisheries are the *Soil and Water Conservation Practices Handbook* and the *Range Analysis Handbook*, which will be discussed later.

The Soil and Water Handbook covers the forest responsibility for management of water quality under the Clean Water Act. Under this act the Forest Service provides guidance to its line officers in providing environmental protection and improvement of water and soil resources and water-related beneficial uses (fish and wildlife). This is spelled out in their national Nonpoint Source Policy, the Forest Service Nonpoint Strategy, and the USDA Nonpoint Source Water Quality Policy.

The Forest Service compliance with water pollution control mandates is addressed through Section 313 of the Clean Water Act and in Executive Order 12580 of January 23, 1987. To comply with Nevada state water quality standards, the Forest Service is required to apply water quality practices that will meet those standards. The Soil and Water Handbook presents a process to develop site-specific conservation practices for use on Forest Service lands to protect the beneficial uses. The handbook describes the application, monitoring, evaluation, and adjustment of conservation practices. The Forest Service is required in this handbook to coordinate all management actions affecting water quality and beneficial uses with state water quality agencies.

Section 208 of the Clean Water Act requires all agencies responsible for carrying out a portion of Nevada's state water quality management plan to be designated as water quality management agencies. The Forest Service has been designated as the water quality management agency for Forest Service lands in Nevada and the handbook provides their guidance.

The Regional Forester has the responsibility of notifying Nevada officials of the results of monitoring and evaluation. The Forest Supervisor must coordinate with appropriate state agencies and monitor the effectiveness of site-specific soil and water conservation practices. The District Ranger will develop and implement the site-specific soil and water conservation practices and monitor the effectiveness of their management programs. They must make the necessary adjustments in any management program not meeting the guidelines of the Handbook. In Nevada these necessary adjustments must be in accordance with your Handbook of Best Management Practices under your Water Quality Management Plan.

The R-4 Range Handbook

The Range Analysis Handbook provides guidelines for the conduct of range analysis, including the suitability, ecological status, resource value ratings, ecological score cards, the determination of range trend, and rangeland monitoring and evaluation. Whenever you want to dig deeper into the Forest Service's responsibility for proper rangeland management ask for FHS 2209.21 R-4, their Range Analysis Handbook. Remember that it is *Range* Analysis Handbook and not range*land* analysis handbook. They define range as all land producing or capable of producing forage for grazing and browsing animals. They define rangeland as all grasslands, shrub lands, and those forest lands which will continually or periodically support an understory of herbaceous or shrubby vegetation that provides multiple uses, one being grazing for animals.

The range analysis portion provides directions for conducting range analysis in a systematic manner. It consists of identifying and mapping ecological sites and the plant species within these sites, suitability for grazing by livestock, and the ecological condition of the range. It provides for the periodic measurement of trend and the monitoring of condition. It further provides for the collection of essential management information related to range improvements, range readiness, and effects from season of use. These are very key analyses that can be included in your decision making processes, as the handbook states that the Forest Service must maintain or improve diversity of plant communities and species, and identify lands *suitable* for grazing and browsing. The present definition of "suitable range" is any range that livestock will naturally graze under specialized management practices and improvements. Suitable range may be in a depleted condition because of past overuse, in which case it may provide little current forage. It is still classified as suitable range. Suitable range not available for grazing because of set-asides by land management decisions are still classified as suitable range. Efforts need to be made to get more of your input into what is and what is not classified as suitable range.

Forest Service definition of unsuitable range is "any area that cannot be grazed by a kind of livestock because of unstable soils, inaccessibility, lack of range improvements, steep topography, barrenness, or inherent low potential for forage production." There is no guidance as to how wildlife and fisheries fit into the identification of suitability. Wildlife and fisheries needs must be imputed by you into the delineation of unsuitable range.

Almost all Nevada national forest grazing lands have been mapped for suitability. Livestock grazing still continues on tens of thousands of acres mapped unsuitable for grazing over 20 years ago. It is questionable in Nevada if any lands with under 8 inches annual precipitation or that have been modified by glacial processes should be grazed at all. This also applies to those riverine-riparian types that if altered cannot heal in our life time.

Great leeway is allowed in the amount of monitoring and the techniques used. The Handbook does, however, have standardized procedures for estimating actual use, and determining grazing capacity without permanent impairment of other resources. A general, but incomplete identification of alternative range management practices is given if needed. Monitoring and evaluation are required at regular intervals. Study results can lead to some interesting, very important discussions and serious thinking on just how the allotment should be managed.

The District Range Conservationist sets the priorities for range analysis based on financial, resource, and manpower considerations. If you have a problem area for fisheries or wildlife, make this known. See that this area or areas are given high priority in the analysis.

WORKING WITH THE BUREAU OF LAND MANAGEMENT

Structural Organization

The Bureau of Land Management (BLM) manages over 85,000 miles of stream fish habitat, many lakes and reservoirs, and a wide variety of unique wildlife habitats. Of the 174 million acres of lands they manage, 84 million acres are in unsatisfactory condition.

The BLM in Nevada sells or offers more AUM's (2,381,606) of forage than any other state in the union (BLM 1988). Six hundred and seventy-four operators graze 43,589,546 acres of land. Of these lands only 4% are classified as being in excellent condition and only 24% are even in good condition. For the most part, BLM rangeland management can only be rated poor. The statutes under which they work provide adequate guidance to managers and cannot be blamed for the condition of the public lands.

Significant improvement in existing conditions is going to be slow because of an inadequately sized work force and lack of commitment and direction from the top. Also, in the 1920's the

Forest Service got rid of some of their grazing problems through reductions and the BLM inherited them.

The BLM is further handicapped in that it receives waters from upstream Forest Service lands which often are already in poor condition. The Forest Service also has its management challenges in maintaining good-condition riverine-riparian habitats. Often the streams and wildlife habitats that border or flow into BLM lands are already in bad shape and then become an even more difficult problem for the BLM to solve.

A major problem has been the organizational structure of the BLM which has not been able to respond to rancher clout, historical habits, and politics. This is a problem that has never been solved but is getting better. The BLM, unlike the Forest Service, has a politically appointed director, who is often a public land user such as a livestock grazer or a logger. The Director answers to the Assistant Secretary of Interior. The political appointments can at times, depress the opportunity to fairly manage fish and wildlife.

BLM PERSONNEL RECOGNIZE THAT THEIR JOBS ARE POLITICAL IN THE SENSE THAT POLITICAL PROCESSES IMPINGE UPON THEIR EFFORTS

Leadership at the top has not always set clear-cut goals. This contributes to the difficulties in problem resolution and field manager support. Some officials have viewed proper and needed fish and wildlife programs as getting in the way of harvesting western forage and timber.

The BLM traditionally has had difficulty making decisions that adversely affect livestock permittees. There are several reasons for this. Most employees that work in the range program have western backgrounds. Many have grown up on a farm or ranch. They have a close attachment to the ranching community and rightfully so. Also, the ranching community is made up of hard-working people who have their heart in what they are doing. It is just natural to help these people at every opportunity. Therefore, there is a tendency to attempt to resolve problems through negotiations rather than by making tough decisions. Often BLM employees must live with their neighbors, especially in small communities. Unpopular decisions can lead to discrimination. When working with BLM employees these facts must be considered and worked around.

Next in line under the Director of the BLM are the State Directors. State Directors do not, in most instances, cross political state boundaries. Almost all BLM lands in Nevada would come under the direction of one State Director. A small portion of Nevada is included in the Susanville District (California), and the Boise District (Idaho) manages a small part of Elko County. Nevada is broken up into 6 Districts (comparable to National Forests), each under the direction of a District Manager. The Districts are sub-divided into two Resource Areas, managed by an Area Resource Manager. When you work at the District and especially the Resource Area levels, you are working with some of the most dedicated and hard-working professional people you will find. Unlike the Forest Service which is very rigid and under strict protocol, BLM personnel at the Resource Area level can do some remarkable things on their own initiative. Sometimes if they are *too* successful, through power politics, it comes back to haunt them.

THE FISHERIES-WILDLIFE PROGRAM IS SEEN AS A COST RATHER THAN AN ASSET AND THEREFORE NOT VITAL TO THE BLM

In my years of working with many BLM personnel at the Resource Area and District levels, I have found that they tried harder to apply good land management than personnel in any other federal agency. I found them to be much more dedicated than their counterparts in the Forest Service, but they frequently had little or no support from higher up, especially when someone got stepped on. You need to encourage and support these people who are trying so hard. Be careful you do not hurt their careers by pushing on them too hard. They can usually have only one fire going at a time. Often their bosses will withdraw support if the issue is politically sensitive. The record is full of reprisals against staff who tried to implement improved riparian management programs in areas with politically powerful permittees (GAO 1988).

Many times field people will provide information that is confidential, and care should be taken to protect this confidentiality. It is essential that a close working relationship be developed.

The fisheries and wildlife work force is small and hidden. The professional staff has declined by almost 70 percent just in recent years, which was done purposely by the top leadership. As a GAO report found, the BLM endorsed a riparian policy and at the same time through not seeking funding increases actually reduced the number of skilled professionals and funds necessary to put the policy in effect. There are efforts under way at this time to correct this deficiency in skilled personnel by asking for higher budgets.

The compartmentalization of specialists whereby the small wildlife-fisheries staff has little or no say in the management of livestock, results in wildlife-fisheries not being integrated into the resource management programs. Although there are many more range conservationists in the BLM than fish and wildlife biologists, even they each have an average of 191,000 acres of land to monitor for changes that are taking or have taken place. It is ludicrous to believe they can accomplish this and still plan and implement balanced resource management programs.

In Nevada, you have only one wildlife biologist on the District Resources staff and one for each Resource Area staff. This compares to 18 wildlife biologists at the field levels and two in the State Office. Fisheries and wildlife biologists are seldom considered to be essential members of interdisciplinary teams that develop planning and management activities. This situation is usually encountered each time you work with the BLM. When it does don't hesitate to let the managers know there is no way they can practice multiple use management or abide by the laws, regulations and stated policies using this approach. Until the wildlife-fisheries programs start showing up in the managers' performance standards, little headway in professional resource management is going to be made.

THE WHOLE STATE OF NEVADA ONLY HAS TWO BLM FISHERIES BIOLOGISTS, AND THEY ONLY SPEND PART OF THEIR TIME ON FISHERIES

At the present time less than 4 percent of BLM funds are allocated for the management of fish and wildlife. In addition, the fisheries program lacks any accountability for where these funds are used. Last year (1989) the BLM spent about $43 million on range management and improvements, but took in only $17.8 million in grazing fees. Funding for the total fish and wildlife program has remained relatively constant at $16 million during the past four years. This is pittance when compared with the Forest Service's $60 million plus to manage less land. Of the $16 million only $1.5 is spent on fisheries. When you add all this up it puts the BLM in a position of trying to conduct supposedly multiple use management without representation from the wildlife-fisheries profession. Thus, they cannot capitalize on fish and riparian habitat management needs, and here is where you can play a valuable role.

The BLM will make a well publicized attempt in the near future to get back into the fishery-wildlife ball game, as they were in the 1970's. Their goal is to implement riparian management, protection, and restoration efforts so than at least 75% of riparian areas are in good or better ecological condition by 1997. This is a simple objective to meet, even with little funding, but the BLM can't be expected to meet it because they haven't even improved 1% within the last decade. This complete effort could be mainly window dressing from the top. In any case, you must urge and support whatever measures are necessary to bring this large bureaucratic organization into balance. It can only benefit the wildlife-fisheries programs. Be prepared to step in with advice and guidance when they stumble as they will not have their own cadre of well-trained people to take over this work load within the space of your career.

BLM Philosophy and Reality

Unfortunately for the BLM, they received the lands they now manage, in an already degraded state. A stronger negative is that almost 60 years after the BLM was formed to try to improve on this degraded state, they have not been successful. The BLM has had some good successes in upland areas and many of these upland ranges are in better condition now than they were 50 years ago. Unfortunately, most riparian areas continued to worsen for lack of decisive action. Because of this philosophy the improvement of riverine-riparian habitats is going to depend more on finally facing up to the problem and then having the drive to move forward with proper management.

Three strong influences shape BLM philosophy: (1) the livestock users and their political allies, (2) the recreationists and their political allies, and (3) the BLM internal personnel with few if any allies. The BLM has been handling these influences by using delaying tactics while they wait for more and better monitoring data before making any decisions. The conflicts are over allocation of resources, not over data. The long delays in waiting for monitoring results only compound the problems they will eventually have to face. The internal forces want to come up with some sort of panacea that will improve riparian habitats but at the same time increase the amount of grazing on BLM lands. This is called for in Resource Planning Act (RPA) goals. This philosophy sounds good but is unrealistic with BLM's person power, money, commitment and resource potentials.

The BLM is understaffed and over-aged. Over-age builds maturity but it puts the "old-time-thinking" in power. The only scientific analysis of BLM philosophy that I know of was conducted on the Vale District. An evaluation of the Vale Rangeland Rehabilitation Program was conducted by Bartlome and Heady (1988). They interviewed 68 employees, which included all the employees on the Vale District.

They found that younger BLM employees (less than 9 years of service) more often believed than did older employees (over 9 years of service) that BLM wildlife-fisheries management needs improvement. Younger employees were twice as positive as older employees that BLM recreation management needs improvement. Newer employees were *much* less likely than longer-term employees (9 vs. 49 percent) to agree that livestock grazing is the best use of public lands.

This study demonstrated that the younger employees are taking a different approach to the management of public lands. They are well trained and can be good proponents of balanced land management.

What BLM Line Officers Consider

As with the Forest Service, the BLM has the responsibility to manage the habitat. Your and their responsibilities overlap. This overlapping offers a great challenge for you to work with their line officers in what they consider their kingdom. As in the Forest Service they must manage fish and wildlife habitat within the context of managing all resources. It is national policy to recognize the state management of resident species. They must initiate active cooperation with Nevada state agencies in all facets of their wildlife program. Their recommendations for wildlife habitat management will be based on state goals for resident wildlife populations. The protection, enhancement, and recovery of threatened and endangered species will receive priority consideration in all BLM activities. Migratory birds and the federally listed threatened and endangered species have become, at least in part, the responsibility of the federal government.

IN LAND USE MANAGEMENT, THERE IS A TENDENCY TO MOTHERHOOD, GENERALIZE, AND PROCRASTINATE

Line officers got where they are because they are team players and "company people." If they disagreed with old established practices, they were not team players. They usually consider first what has always proven good for the agency. The rules are changing somewhat, in that they must for the first time, begin to consider what is good for the public and the resource. The reluctance of the Bureau to allocate forage for wildlife, especially big game, is a prime example of the results of the team player approach. The current monitoring mode of the BLM is not beneficial to fisheries and wildlife, and until change occurs, these resources will not receive the recognition required to meet their demand for forage.

The BLM must have public support if it is to be a viable agency. The livestock user can no longer carry it through the political arena. You can use this to your advantage by contributing professional knowledge and integrity to resource management and thus gaining the needed public support. Do this in cooperation with the Area and District Managers. What makes them look good can also make you look good, but most important the wildlife-fishery resource will benefit. There is a real need to get the public more involved in BLM matters. It's such a busy world this is hard to do but it's worth the effort.

WORK TOGETHER -- THIS PUTS FEARS TO REST

Something that won't make you popular, but needs to be done anyway, is to get the BLM off the monitoring-holding ploy and on to doing something constructive on the ground. Most decisions should not be delayed any longer. There is more knowledge around today than the agency would like to admit.

Riparian Policy

The BLM knows how to restore and manage riparian habitats. There are no breakthroughs from research needed to guide good land management. The land is now dotted with representative successful projects that can be interpolated over broad land areas. There is nothing except person power, money, and commitment at the top standing in the way of the BLM putting its riparian policy into effect and beginning to reap the rewards.

The BLM Director, surprisingly, has signed off on a riparian policy to maintain, restore, or improve riparian areas to achieve a healthy and productive ecological condition for maximum long-term benefits. Each state has developed its own riparian management strategy. The policy and strategies call for achieving riparian area improvement under existing uses wherever possible. You can live with this as there are proven ways to do it under most circumstances.

The policy requires that any new or revised resource plans recognize and include the importance of riparian areas. NDOW specialists should make sure that land use plan objectives are site-specific. They must be measurable and achievable, and then the manager should be pushed to meet them. All management activities must be revised where site-specific objectives are not being met. This policy is strong medicine and it can constantly be used to your advantage if you understand it, know how to work with it, and urge its application. Also, each District is required to develop a riparian demonstration area, where BMP's and instream habitat repair projects will be demonstrated. You can not only help in identifying where these projects should be, but use them to demonstrate the benefits of good management. You should make sure, however, that stream repair projects do not get in the way of good land stewardship. All repair projects must be followed up and the results documented.

The need in Nevada for implementing the riparian policy is well justified by the BLM's own task force report on the condition of Nevada's ranges (BLM 1974). In summary the report states that:

1. Uncontrolled, unregulated, unplanned livestock use is occurring in approximately 85 percent of the state and damage to wildlife (including fisheries) habitat can be expressed only as extreme destruction.
2. Stream riparian habitat where livestock grazing is occurring has been grazed out of existence.

This report is as valid today as it was in 1974 as riparian areas have worsened instead of improving since this date.

Regardless of these findings, and if you have been doing your homework in reviewing the many BLM EIS's, you have found that there is little in these plans that will improve riparian habitats. We must all ask ourselves where we were when we were so badly needed to set the record straight during the EIS process. Many groups are still skeptical of the BLM's overall commitment to riparian management.

A positive note is the Fisheries Goals and Objectives under "Fish and Wildlife 2000" that evolved as a result of the riparian policy. The goal of this report is to establish the direction needed for management of riparian areas so as to achieve healthy and productive conditions for long-term benefits and values. Of course it has to done in concert with the range and watershed programs. A new BLM Director has just come on board who appears at this time to look upon this new effort with favor.

Objectives of the program are to implement current land use plans for species or habitats identified as important to local communities. Of course it must be done within time frames established by BLM managers. Emphasis is placed on coordinated management approaches for fish species and their habitats, where needs have been identified through the BLM land use planning process, or by cooperating agencies. The program calls for maintaining or enhancing important fisheries resources by implementing habitat management or improvement projects identified during the planning process, but in accordance with priorities established by management. By now you can see there are some bureaucratic safety valves and constraints attached to the goals and objectives and this is where you can help the program out -- by seeing that management puts these goals and objectives in their true order of importance.

The FY 1986, 1987, and 1988 Annual Work Plan Directives to field offices established management of riparian/wetland areas as one of the highest priorities in BLM fish and wildlife, watershed, and range management programs. This is strong direction that has not often come from the top. It may be a sign of change. If so, it can only increase the riparian consciousness among BLM resource specialists, an outlook that is especially needed in managers. Now is the time for strong management commitment and support.

Legal Requirements

There are at least 30 legislative acts, six Executive Orders and several Bureau manual sections that provide direction to BLM for the management of riparian aquatic resources on public lands. Lack of legal backing to conduct proper land management is not a constraint. The basic legislative authority for carrying out the grazing program is the Taylor Grazing Act, passed way back in 1934. The purpose of the Act, to stop the degradation of the Nation's ranges, was very timely. Because there were no advocates in the mid-1930's for wildlife and fisheries, the nearly sole objective of the Taylor Grazing Act was to stabilize the livestock industry. All resulting policies and regulations were developed between the livestock industry and the BLM alone.

The Act called for little planning and hardly any took place the first two decades after passage. Fishery, wildlife, and watershed values were usually always ignored in decision making. The Taylor Grazing Act was purposely drafted to mesh with the custodial phase of livestock management and to guide the adjudication stage. The Act was not advanced enough in new thinking to guide the BLM through the intensive management stage of the 1960's and 1970's. Therefore, it completely failed the environmental phase of the 1980's. The Act is now outdated and should be done away with. It is slowly being replaced by such legislation as the Federal Land Policy and Management Act of 1976. Probably the most significant results of the Taylor Grazing Act were the elimination of transient livestock herds and the establishment of administrative districts and livestock grazing allotments.

The Federal Land Policy and Management Act (FLPMA)

With the passage of FLPMA, the BLM received for the first time, permanent authority to retain and manage fisheries and wildlife in multiple use management. The Act, now over a decade old, remains the basic guide for management of fish and wildlife habitat on BLM lands. It places fish and wildlife on an equal footing with all other uses, requires that fish and wildlife needs be considered in all land exchanges, and authorizes designation of "Critical Areas of Environmental Concern." The Act establishes that livestock grazing should be on an equal footing with wildlife and fish in all planning and decision making. Section 401 (b)(1) of the Act authorizes the use of range betterment funds for the protection, maintenance, rehabilitation, improvement, and management of wildlife habitat. Wildlife and fisheries habitat must also be protected pursuant to the management prescriptions specified in Resource Management Plans (RMP's) and Habitat Management Plans (HMP's).

FLPMA required the BLM to conduct inventories of all public land resources. It must prepare comprehensive land use plans that include fish and wildlife as equal uses. FLPMA also requires BLM to prepare Environmental Impact Statements on all major actions that could affect the environment. FLPMA is now about 12 years old but it has not resulted in any measurable improvement in riverine-riparian lands.

FLPMA requires monitoring of land use plans. BLM policy is to complete rangeland monitoring and issue grazing decisions within

5 years after completion of an EIS. The 5-year period is almost over for many areas. This means the "time out period" is over and it is time for the BLM to "fish or cut bait." Because all grazing actions must now conform with existing land use plans, interested parties should obtain land use plans and review them for consistency with management actions. The plan should identify the issues grazing decisions should address. Participate in on-the-ground reviews and identify those areas where grazing decisions are not in compliance with wildlife and fisheries needs. Also, early in the game ask them to describe what management objectives will be monitored, what monitoring methods will be used, and how the monitoring is to be done. The BLM does not have the capabilities (funds and physical resources) to conduct the required level of monitoring and evaluation. This puts them in a poor position and I feel sorry for them, but the law is the law. They must give equal consideration to fish and wildlife habitat in all decision making and follow up with appropriate management. They should not continue to degrade riverine-riparian resources.

As stated before, the first thing to do is identify the decision maker. Often that person will stay way in the background and let the staff bear the brunt of the public contact. Once the decision maker has been identified, keep on good terms with him or her. Remember it's a tough job to mesh lawful mandates of the multiple use politics with everyday living. Your job is to simply see that they abide by their mandates. They have to face the political consequences.

Public Rangeland Improvement Act (PRIA)

PRIA, passed in 1978, nominally supplements FLPMA and reaffirms the position and authority of grazing advisory boards, and long-term leases for grazing permittees. The "McClure Amendment" to the 1979 appropriations for this Act didn't make the job any easier. This amendment restricted any reduction in the numbers of animals permitted to graze an allotment to 10 percent annually irrespective of what was contained in the EIS. This may come back to haunt us, but the move to proper rangeland management can often be done without any reduction in livestock numbers. It is mostly just a matter of finally getting and maintaining some proper management on the ground. Good management seems to come in infrequent pulses with poor management filling the voids. There have been some good programs put into effect, but with continued changes in livestock programs and personnel or loss of support from the top, good programs have often gone by the wayside. A good example was the BLM'S Vale Project in Oregon. This was a good project and much was accomplished about 15 years ago. This project may have siphoned off more money than the BLM has put into any other single project, but it was successful. Then commitment and funding dried up and today the Vale Project riparian habitats are in shambles.

Working with the NEPA Process

The 1967 National Environmental Policy Act provided the major impetus for hiring fisheries biologists and some wildlife biologists in the BLM. This required for the first time that the BLM conduct Environmental Assessments of its issuance of livestock grazing licenses, their land management plans and other actions. The BLM must make a concise record of any decision coming out of the NEPA process. You should check this record on all major actions affecting fisheries-wildlife resources, and make sure they were adequately addressed in the planning process. NEPA has been in effect for about 20 years now and it has been recorded that BLM rangelands have improved by only 1 percent during that period. This exemplifies that the rehabilitation of riverine-riparian habitats will require something different than what has been done in the past. The NEPA process, implemented adequately and with follow-up decisions and monitoring, can bring about the necessary changes.

EIS's

The BLM has had a massive program of preparing court-ordered EIS's since the early 1970's to assess the impacts of livestock grazing. The inventories may have been quite good but the end results have had little effect. The BLM has never had the full multiple-resource inventories, however, to properly assess existing resources. Therefore, forage allocations and other key decisions affecting wildlife-fisheries are mainly incomplete or "business as usual." Help them out whenever you can with your data base and also input into their decision making.

Other Acts

Two other acts play an important part in the BLM's wildlife-fisheries program. The first is the *Sikes Act* in which Congress mandated the BLM to plan, develop, maintain, and coordinate programs for the conservation and rehabilitation of fish and wildlife habitats. The Sikes Act was never funded adequately, but what money did come down the pike was utilized for the development of habitat management plans in cooperation with the states. You should be brought in on any of the planning and implementation stages -- if you are not, find out why. The Sikes Act requires cooperative BLM-state efforts for the conservation and rehabilitation of wildlife-fisheries resources on the public lands. Cooperative agreements have already been signed with NDOW.

The second act is the *Endangered Species Act* which provides for the protection of listed and potentially listed plant and animal species and their habitats. Many of the listed fish species in the West are on BLM lands, and Nevada has its share.

The BLM has two major responsibilities under this Act. One is to seek means to ensure recovery of listed species on BLM lands. The other is to ensure that any federal action authorized, funded, or carried out (including livestock grazing) is not likely to jeopardize the continued existence of T&E species or result in destruction or adverse modification of critical habitat. The mandatory requirements of the Endangered Species Act have the potential for imposing major constraints on other uses of the public lands. There is usually little managerial discretion for carrying out any program that conflicts with T&E objectives.

Executive Order (EO) number 11990 made in 1977 directs federal agencies to minimize the destruction, loss, and degradation of wetlands and to preserve and enhance the beneficial values of wetlands. EO number 11988 made in 1977 instructs all federal agencies to restore and preserve the natural and beneficial values of floodplains.

Executive Orders and Policy Statements

Executive Orders and Policy Statements also require the BLM to manage fish and wildlife resources within a multiple use framework without any long-term loss of habitat capability. Special attention is given to aquatic resources with unique values. Direction for the management of fisheries and wildlife habitat is identified in the BLM's land use planning process. Land use decisions are implemented on the ground through site-specific plans and through fish and/or wildlife habitat management plans. Monitoring and evaluation are an essential part of all plans.

Protests and Appeals

All land use plans can be appealed. You will seldom enter into this process, as your major responsibility is to make sure that the land use plans are adequate in the first place. Because the public will be appealing land use plans you should understand the appeal process and what influences it could have on wildlife-fisheries resources. Study the BLM's planning regulations. Every Forest Plan has been appealed. The appeal process is slow but almost always gives the managers a different, valuable perspective on their decisions.

Appeals to BLM plans are filed with the State Director with a copy to the respective Field Solicitor. Reasons for the appeal must be stated, and appellants must have participated in the planning process to qualify for an appeal. The Director's decision is final on this appeal and if you are not in agreement with his or her decision, the only recourse is to take it out of administrative appeal and into the courts. These actions can be costly in time and money and can influence your management time schedules.

Monitoring

In 1980 the BLM, because of its large problem with preparation of EIS's and the public concerns over "one time inventories" went into a 5-year monitoring program. There was great animosity building in Nevada on the BLM's approach to making livestock reductions. The change in direction to monitoring was supposedly to provide a consistent supportable approach to making management changes and improve the working relationships with other entities. The BLM worked with the Nevada Range Studies Task Group to cooperatively develop a consistent, technically adequate, and cost-effective set of rangeland monitoring procedures for approximately 46,000,000 acres of BLM-administered public land in Nevada. It is now ten years later, and undoubtedly, the rangeland is in as poor shape now as it was then. There may have been some procedures developed that could change this situation. Time will tell, but the public should not put up with this situation forever.

The monitoring procedures in the "Nevada Rangeland Monitoring Handbook" are supposedly sound and can be implemented into the coordinated planning approach used on each BLM District. The state BLM office staff reviews the processes used on the ground and supposedly makes sure coordinated planning is consistent and technically sound. Managers must still evaluate present management at the allotment level to determine if land use planning objectives are being met. The approach appears to be sound but the proof of the pudding is in performance and needed results. Your work on evaluating wildlife-fisheries habitats will serve to prove if present or proposed management will accomplish wildlife-fisheries objectives. You should constantly share your findings with them to demonstrate if progression toward established objectives is being made. During 1987 and 1988 in Nevada, it is doubtful if any betterment resulted in riverine-riparian habitats because of climatic conditions. Hopefully just after the turn of this decade we will notice some improvement. If not, it's back to the drawing boards for all managers.

Allotment Management Plans

In the 1960's the BLM adopted the concept of "Allotment Management Plans" (AMPs). (See also the section on Allotment Management Plans under "Working with the Forest Service," p. III-18.) The plans are written in consultation with affected permittees. In the beginning the plan was simply an application of some type of grazing strategy designed around some recognized physiological requirements of the livestock's key forage species. In the early 1970's some AMPs were challenged because they accomplished livestock management objectives but failed to meet other resource objectives.

AMP's levels of grazing use for livestock were monitored on the basis of Class 1 grazing privileges and range condition and trend. Unfortunately the well-being of wildlife-fisheries resources has often not been adequately incorporated into condition and trend of livestock management objectives. This is especially true if management objectives are only established and monitored in the uplands. The plan calls for a description in detail of how the grazing operations are affecting fish, wildlife, watershed, and recreation values. It is very key that you obtain and read this portion of the plan. The first thing to do is look for land use plan objectives. You will find that most plans are outdated. Plans were put together with only the permittees' input, and many were developed without consideration for other resource values.

If the plan is not adequate, request that an updated AMP be completed under an interdisciplinary approach. The famed BLM Nevada Report (1974) found the majority of their AMP's failed to adequately identify or specifically provide for non-livestock resources. It is your fault if the BLM in your area continues to allow livestock grazing under out-of-date AMP's. You can make a difference, especially when you keep pointing out that grazing levels in an allotment are at the upper reaches of of proper utilization. Thus, when natural events such as drought or grasshopper infestations occur, there is no "safety valve" and almost always the range suffers, but the non-livestock grazing resources and values suffer first and most.

One of the most key things you can do at the outset is to insist that the BLM use ungrazed allotments to take pressure off problem allotments. When an allotment is in need of rehabilitation, fire wipes out a forage producing area, or low precipitation years just do not produce the forage necessary to prevent overgrazing, then the ungrazed allotment could be utilized until the other allotment is rehabilitated. This nonuse principal goes against the whole philosophy of BLM thinking, but it would do more good for wildlife-fisheries resources than anything else we could do at this time. When an allotment goes into nonuse or is given up -- jump on it and request that BLM set it aside for rehabilitating other allotments with problems. Everyone knows there will always be problem allotments in the future. It's time the BLM created some safety valves to take the pressure off.

The BLM has an Allotment Management Handbook that you should become familiar with. Review this handbook before you participate in the review of any allotment in your area. State and District Office staffs are required to conduct occasional quality control field reviews in selected Resource Areas. You can be part of this procedure by asking to participate on the evaluation team.

A Strategy for the Future

In 1987 the BLM Director approved a program "Fish and Wildlife 2000: A Plan for the Future," developed mainly internally by BLM personnel. It's a good document and sets forth goals and objectives for more effective management of fish and wildlife resources. There are some real pluses in this program that if carried through would benefit your working relations with the BLM, and more importantly benefit the fishery resources. "Strategy for the Future" calls for a strong partnership with state fish and wildlife agencies. You should use this to your mutual advantage. Never have wildlife-fisheries on BLM-administered public lands received their fair share of consideration and if this program can increase their share, it is worthy of your support. The BLM has started off running on many occasions, but never finished. Your input can help this program make it to the finish line.

The Fisheries-Wildlife Manual

The BLM, like the Forest Service, is undressed when not surrounded with its manuals. Their manuals are used constantly for direction and to guide implementation. Sections 6500 to 6900 pertain to the management of fish and wildlife. These sections should be on your bookshelf for constant review, and can be acquired from the District wildlife staff or the wildlife staff in the State Office. This manual requires the BLM to work closely with you. You should not receive any surprises from them and if you do, you should refer them back to their own manual. In addition, the BLM has handbooks and other guidance material which is outdated.

PEOPLE DO NOT DETERMINE WHO IS DOING A GOOD JOB -- THE LAND REVEALS WHO IS DOING A GOOD JOB

Nevada BLM has an NSO manual supplement #6672 on stream surveys you should be familiar with. Because livestock grazing is so widespread, you should be familiar with their grazing regulations, 43 CFR-4100. Often the BLM does not follow these regulations and gets away with it because no one else is tracking the results.

Do not depend on the BLM to have proper manual and guidebook guidance -- as with the Forest Service, it's just not there. The Forest Service may ignore its abundant guidance direction but the BLM always has sufficient guidance to ignore. This is one area you could improve by working your regional wildlife-fishery needs into their coming guides.

The BLM does develop habitat management plans that provide for specific management of select areas with wildlife resources. I used to ask -- which has preference the habitat management plan or the allotment management plan, as they often conflict. No sensible answer was ever given. Keep a file of all (you won't find many) habitat management plans for your area and each time you are on an allotment review, pull them out to see if the plans are consistent and proper management has been applied. Also, the habitat management plans will help identify the need to update any allotment management plan which is outdated.

BLM manuals you should be especially familiar with are:

1737	Riparian Wetland Area Management
6820	Fish, Wildlife, Plant Introductions, Transplants, Augmentations and Re-establishment
6780	Habitat Management Plans
6840	Special Status Species Management

Habitat management plans should be monitored the same as AMP's to see if they are meeting their objectives. NDOW signs all HMP's and receives a copy, so it is as much their responsibility to follow up HMP's as it is the BLM's.

Summary

In working with the BLM, first approach it as a partnership with the assumption that both of your agencies are trying to do good management. Then identify the office and the person(s) responsible for making those decisions affecting fish and wildlife. This process is needed because you only have so much time to spend on any given project, so make every second pay off. Make personal contact with this decision maker to develop better working relationships. At the same time, work closely with other staff members responsible for fish and wildlife.

Take detailed notes, even on phone calls via telephone confirmation slips, to build a written record. Verbal communication is very valuable, but the important verbal parts that may come back to haunt you must be put in the written record. File these records and all letters you send and also all those received so you can be well briefed prior to attending meetings or field reviews.

When decisions go up the line for final review and approval, keep your supervisor informed of the timing and of where he is in the decision making process. Always provide the BLM straight facts, without sentiment, on all fishery-wildlife related issues. Purposely keep them informed; thus, you will gain the reputation of being a strong and dependable person who is on top of the situation. They may not like your input and some of the "red meat" syndrome people may even dislike having you around, but they will *respect* and worry about you.

When working directly with a Range Conservationist at the field level, politely encourage him or her to maintain as much management flexibility as possible. This is especially important for determining those ranges that should be grazed during what periods and with what timing and frequency. In this process keep trying to get livestock use transferred, as much as possible, away from riparian areas and onto seedings. Foster a cooperative working relationship with the permittees but do so in conjunction with the Range Conservationist. He or she has to work with them year around, you don't. Do not make their job any more difficult than it is already. Always hold out for strong, proper riverine-riparian management; the law is on your side. Make sure you think, act, and talk as a concerned person with valuable information -- do *not* act like a law enforcement officer.

WORKING WITH THE EPA

The U. S. Environmental Protection Agency (EPA) is responsible for implementing the federal laws designed to protect the environment. At the present time they are one of the few Federal Agencies with "guts" and are doing an excellent job of building awareness and action towards taking care of the Nation's water problems. The problem with assistance from EPA is that they do not relate well to riparian habitat, and if riparian cannot be included under their "wetland" designations, it doesn't get much notice. Section 404 of the Clean Water Act gives them strong "wetlands" direction.

They are an agency to look to for assistance, however, as they are the instrumental agency in applying and assisting the states with the application and enforcement of the Water Quality Act.

The EPA administers and enforces nine comprehensive environmental protection laws of which the Clean Water Act, the Comprehensive Environmental Response, Compensation and Liability Act, and the Resource and Recovery Act are included. There currently is no comprehensive federal law for protecting riparian habitats that comes under the EPA's jurisdiction. The Clean Water Act is about the only one that has application to riverine-riparian systems. The goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's water. When the EPA finally acknowledges that without the proper management of riparian systems and adjacent uplands, their goal cannot be met, then we may see some emphasis by the EPA for proper riparian management.

EPA Administrators cooperate closely with your state to make sure that state needs are considered in the implementation of federal environmental laws. The Water Quality Act of 1987 requires the EPA to work with the states so they report waters impaired due to nonpoint sources. The states must identify the type of sources causing the problems and develop state and local control programs to solve these problems. The states must develop programs for controlling nonpoint source pollution including methods and a time frame for remedying problems. With the large emphasis on toxic waste, radiation, global warming, and ozone depletion, livestock grazing has had a hard time getting its fair attention in nonpoint source analysis.

The EPA Regional Office that administers EPA functions in Nevada is located at EPA Region 9, 215 Fremont Street, San Francisco CA 974-8071.

The closest EPA Research Facility is located at Environmental Monitoring Systems Laboratory, P.O. Box 15027, Las Vegas, NV 89114.

The EPA is striving towards a proper balance in working with states. They are providing better guidance and technical support to state governments in protecting aquatic environments. They are providing training and technical opportunities that you should be taking advantage of.

Under EPA guidelines the State of Nevada adopts water quality standards for every stream within its borders. These standards include fishing as a designated use and therefore, there are prescriptions made to protect this use. The criteria are pollutant specific and represent the permissible levels of substances in the waters that would enable the use to be achieved. Water quality standards are the basis for nearly all water quality management decisions.

Because water quality standards may not be the problem in livestock grazing impacts, EPA-directed guidelines seldom go far enough to be of much benefit. As the Water Quality Act is better interpreted and amended, it will be the major direction as to how BMP'S are to be designed and implemented for building compatible livestock grazing practices. Water quality standards are reviewed every three years and modified to fit the needs, so there is an opportunity for needed improvement.

The EPA has only recently started to focus on critical aquatic habitats as a major environmental problem. The initial focus is on problem recognition, developing new program strategies, and development of protection technologies. This program is slowly developing but has not acknowledged livestock grazing impacts as a factor affecting critical habitats. In the future the EPA will have to address livestock grazing, and when they do there will be much more emphasis in applying compatible BMP's.

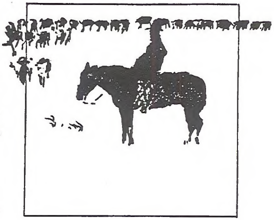
WORKING WITH RANCHERS

INTRODUCTION

The value of a professional biologist is measured by his or her results. Results are rarely produced by one person. Results almost invariably come from a synergistic interaction of one or more individuals. You as the fish and wildlife professional can bring into this interaction essential biological understanding. Your ability to communicate this understanding is the key to its contributing to the quality of the end product.

You communicate within your agency every day. This communication is shared through training, education and personal philosophies. This type of communication is usually easy. Working for your Department, however, requires that you communicate outside of your comfortable group. You will be called on constantly to communicate with ranchers and livestock managers with dissimilar training and education, vocabulary, objectives, and personal philosophies. This is when your ability to be the "Great Communicator" comes into play.

Today's rancher knows that he or she lives in a complex, changing world that presents an uncertain future for not only his economic livelihood, but his entire way of life. Ranching is a land use introduced to the western United States by the Spanish in the 1500's. Ranching has become increasingly complex over these almost 400 years. Nonetheless, the romantic concept of turning livestock onto range and then answering to no one lives on.



Today's rancher's changing world has him or her answering to a myriad of economic and legal realities that are often contradictory. His banker requires him to maximize his profits in order to qualify for a loan. His BLM grazing permit, requires him to turn out too early, not graze many cattle, and not utilize the riparian vegetation over 50%. On the one hand he owns and operates a business that operates in a global market and produces the food essential to our nation. On the other hand, he is a hold-out agriculturalist in a post-industrial society.

The biologist is oftentimes just another messenger of change. You rarely will be blessed with telling the rancher that you have a lot of other people's money that you can share with him to enhance his operation. Many times, your job will be explaining hard choices and trying to cooperatively identify the most preferable and often unpleasant alternative. The rancher knows that the future of range livestock grazing is tenuous. Both economics and social pressures are brought to bear on his success. His future relies on how effectively he is able to satisfy the BLM or Forest Service range administrator. In the future ranching will only continue on public lands if it is continually accepted by the American public. I believe the public will continue to accept it only under tighter and tighter restrictions.

Do's and Don'ts

Do:

Understand where the rancher is coming from

•

Know where your role is in the negotiations

•

Meet and deal, but remain professional

•

Use good manners

•

Don't:

Underestimate the rancher!

•

Most ranching operations are just now beginning to accept payment for the environmental and social costs of their operations. Livestock grazing has degraded many riverine-riparian habitats in Nevada. Reining in these continuing excesses in a cooperative atmosphere will be the measure of your effectiveness.

Take careful note of the simple *Do's and Don'ts* on communicating with ranchers which are included here.

An important thing to keep in the back of your mind and keep you humble is that the rancher will almost always be smarter than you are. I have found them usually to be more than my equal. That is why they are running the multi-million dollar operation and not me. If they were not smart they would not be in business. Nothing defeats you quicker than underestimating the person you are working with.

Understanding Ranchers

Ranchers share with you a love of the wide open spaces. Like most biologists they are not in business for the money, they love the lifestyle. The quality of life available to ranchers is very important. They especially value such intangibles as raising a family on a ranch. Those of us who must do this in the big cities envy their opportunities. In the past net returns to investment on western ranches have been low and many times negative. The past three years have been much more favorable. A recent study of 313 ranchers in Colorado grazing on public lands found that 75% would not consider selling their ranches in the current market. Further, for over one-half of them, rate of return was of little or no importance in their decision to be in the cattle business. They are very dedicated to what they are doing and feel good about it.

In addition, many ranchers still feel they have a vested right in the public lands; that these public lands have historically been a part of their base property. Thus, they will often feel that you, as an outsider, are trying to take away something that is theirs.

Knowing Your Role

In your role as a state biologist, do not step into the role of administrator of any rancher's grazing permits. All negotiations regarding an Allotment Management Plan or a grazing permit are the responsibility of the BLM or Forest Service employee assigned to that rancher's grazing permit. You can, however, encourage your federal counterpart to negotiate in a particular fashion with his permittee if you can justify your position with good logic and a good data base. By staying out of the administrator's role, you are not directly identified with the bumbling, red-tape bureaucracies ranchers have to work with. This allows you to function in a nonterritorial sense.

Always remember that the natural resource base will usually benefit over the long term through more cooperation and less confrontation. Trust is not easily acquired. Without trust, there will be no management. Without agreement there will be no commitment. And without commitment, nothing will be done.

Negotiating

Good business manners and straight-forward communication will help you achieve your goals. Recommended basics are:

1. Meet the rancher at the ranch on his own turf.

2. Shake hands, look him in the eye while talking to him, and clearly state your business.

3. Ask for his viewpoint and knowledge as you state your reasoning. Frame your references to common knowledge; for example, about what has been done on similar allotments.

4. Trust his sincerity. Ranchers probably have the best reputation of all disciplines for being sincere in what they believe.

5. Make sure you know what your supervisor will approve. Do not get into areas outside of this approval. If higher-ups veto

WITHOUT TRUST, THERE WILL BE NO MANAGEMENT; WITHOUT AGREEMENT, THERE WILL BE NO COMMITMENT; AND WITHOUT COMMITMENT, NOTHING WILL BE DONE

your agreements with the rancher, your image and trustworthiness has been tarnished -- not theirs.

6. Don't ever threaten. Ranchers won the West going up against men and women tougher than we are. You'll achieve more success with the rancher's help than in the face of his opposition.

7. After every professional interaction with the rancher where good faith was attained in considering good fish and wildlife management, thank him for his efforts. Follow up with a card or letter. Set up a good framework for future work, as seldom will you make the needed headway in one meeting.

8. Money and quality of life make the world go around. It's like sex in that the lack of it keeps it constantly on your mind. The rancher has the quality of life; you must make sure your proposals fit in with his need to be solvent and financially secure. In formulating your proposals, figure out the most painless way for the rancher to implement the solution. Does his BLM or Forest Service office have range betterment funds to pass on to him? Can your agency pass on Wallop-Breaux monies to him? Can the Rocky Mountain Elk Foundation or any other similar organization provide a grant? Will volunteer labor be available to help on the project when needed? Most ranchers will have the same response as you would when asked to contribute several thousand dollars to a fish or wildlife project. There is little if any cash return for his benefit.

9. Never underestimate the rancher you are working with. Through economic selection over the past hundred years, those now left are capable of profitably running a million-dollar business in a complex, adversarial environment. Their daily demands would quickly defeat a great many of us agency personnel. No matter how unimpressive a rancher may appear, he is likely to:

a. Have good contacts with key county, state, and national political entities. If he doesn't, his neighbor does.

b. Be able to understand whatever proposal you present in biological, economic, and practical terms. He is likely to cross-check his understanding of your ideas with your supervisor, his attorney, or his accountant.

c. Be able to mobilize local opinion behind his industry since local economies may be dependent upon livestock production.

Practicing Professionalism

Always give the best advice you can. If you do not have the answers, find them and return with them as quickly as possible. Your success usually equals the energy you put into it. Always be straight-forward. Cunning is only good in very short relationships.

Most ranchers are some of the most helpful, considerate, personable people in the world. They were raised in an environment where success results from hard, honest work where they had to be good-natured enough to give and take with family, coworkers, and neighbors. Dealing with miserable weather and oftentimes ornery livestock reinforces this philosophic necessity. Today's regulatory environment is the antitheses of this. Where once things were handled with a handshake and trust, now things must be done by the letter of the law.

Never send cold letters without first trying to settle face to face. Do this on the rancher's property. Always try to deal with the rancher in person. If this doesn't work get on the phone. If you have to leave messages with the rancher's family make sure they are positive. For example, "We finally got the funding to help you out on the riparian project." If the message is negative, hold it until you can deliver it straight and direct.

Summary

Letters to the editors illustrate much of the dilemma we are now in. One letter alleges that ranchers are subsidized range robbers destroying our rangeland resources while asking us to eat more beef. The rancher responds that they are real people just like you. They enjoy many of the same pastimes. They are concerned about the environment. They know that without soil and water, there will be no grass. They try to be good stewards of the land. They are a vital part of the state economy. They are advocates of multiple use and respect the rights of others on public lands. In turn they want others to respect their rights. In this case I would take the ranchers' side. They are ready to be good stewards. They need cooperation and assistance. A lot of work remains undone. This is where you come in.

CASE HISTORIES

INTRODUCTION

Case histories involving livestock grazing on riparian areas are given for surrounding western states that have environments and problems similar to Nevada's. The elevation and climatic conditions are included so you can compare these conditions to your area. The most important part of this analysis are the shaded summaries that accompany each history. The summaries represent a learning experience based on years of work by your colleagues. They should give you some ideas and approaches that have application in your area. Most of these case histories were taken from a document prepared for the Environmental Protection Agency under the title "*Livestock Grazing On Western Riparian Areas* " by Ed Chaney, Wayne Elmore, and myself.

Arizona: Sedow Allotment

The Sedow Allotment has been grazed by livestock since the mid-1800's. Intensive, unregulated grazing in the early years severely depleted uplands and riparian areas of native vegetation. This resulted in the familiar chain reaction of events leading to deterioration of watersheds and lowering of productivity. In the late 1970's managers took steps to improve upland vegetation and encouraged regeneration of cottonwood, willow and other vegetation in the largely denuded riparian areas. Grazing strategies were designed to fit specific site potential and condition. A number of grazing allotments were switched from a continuous season-long strategy to a modified three-pasture rest-rotation strategy providing high intensity, short duration grazing and spring-summer rest two out of every three years.

The 34,800 acre allotment is at about 5,000 feet elevation. Precipitation is approximately 19 inches per year. About 60% occurs in winter. Vegetation ranges from semi-desert grasses to chaparral-juniper. In 1978, riparian areas with potential for cottonwood and willow were characterized by a few large decadent trees scattered along otherwise bare streambanks. In one study area there were no cottonwood or willow between 0.25 and 25.9 inches in diameter. Grazing was reduced on the allotment by 50% and the modified three-pasture rest-rotation strategy implemented.

Sedow Allotment:

Decades of improper livestock grazing on riparian areas reduced woody plants to widely scattered, decadent trees which provided a source of seed, but continuous heavy livestock grazing eliminated young plants.

The Sedow Allotment was so overstocked a drastic reduction in livestock numbers in addition to a new grazing strategy was required to improve upland and riparian vegetation.

By 1984 upland vegetation had improved. In addition cottonwood and willow and other riparian vegetation had regenerated in profusion. There were now more than 1,000 cottonwoods and 3,200 willows (0.25-25.9 inches in diameter) per 100 acres where previously there were none.

In 1987 the livestock permittee remarked that he had been on the allotment for more than 50 years and that the riparian areas had "always looked bad." Those areas which had been nothing but sandy draws for decades now had flowing water and abundant vegetation and wildlife.

A nearby allotment, the Roosevelt Allotment, is located at about 4,000 feet elevation. Precipitation is approximately 10 inches per year. Upland vegetation is characterized by semi-desert grasses, prickly pear, and cholla. Riparian vegetation is dominated by cottonwood, willow and sycamore.

The livestock permittee on this allotment had voluntarily reduced numbers of livestock without studies or procedural delay. The problem was obvious and he was concerned about the long-term productivity of the land and value of the grazing permit his children would inherit. Upland vegetation benefitted from this stewardship. Riparian vegetation remained in largely deteriorated condition.

Implementing a modified three-pasture rest-rotation strategy resulted in cottonwoods increasing from 20 per 100 acres in 1978 to more than 2,000 in 1984. Willow increased from 28 to 225 per 100 acres. These results occurred concurrent with a 27% increase in the amount of livestock forage grazed from the allotment.

Idaho: Henry's Lake Area

Henry's Lake and immediately adjacent grazing lands are at about 6,500 feet elevation. Annual precipitation averages about thirty inches and comes mainly as snow. Peak runoff in tributary streams generally occurs in mid June. Lake-side pastures have been grazed since the late 1800's from about mid May until early October.

Henry's Lake is fed by numerous large springs. Several small tributary streams provide spawning habitat for cutthroat and brook trout. Juvenile fish migrate to the lake, grow to large size and attract anglers from around the world.

Sedow Allotment, cont'd

On the significantly more arid Roosevelt Allotment, animal numbers were in better balance with available upland forage, but riparian vegetation was severely deteriorated. Implementing an improved grazing strategy produced more livestock forage while restoring riparian vegetation.

The permittee on the Sedow Allotment resisted reducing animal numbers and changing grazing strategy, partly because in his half-century on the allotment, riparian areas had "always" looked the way they did in 1978.

The necessary changes in grazing management on these allotments were encouraged by the National Audubon Society. They threatened to sue the Forest Service because improper grazing prevented regeneration of trees essential to nesting bald eagles.

The riparian healing process began and progressed most rapidly in the higher elevation upper watershed. Riparian recovery in lower areas was retarded by rapid runoff from deteriorated uplands which were slower to recover than riparian areas.

The once world-renowned fishery in the lake declined precipitously over the past two decades. Livestock grazing of tributary riparian areas was identified as a significant contributing factor. Livestock had depleted streamside vegetation and trampled streambanks. Summer water temperatures had increased, streambanks were eroding, and trout spawning gravels were smothered with sediment. Streams carried small but cumulatively significant amounts of livestock manure and urine into the shallow, naturally nutrient-rich lake. This accelerated the natural aging process.

The Fish and Game Department developed a plan to rehabilitate the lake fishery. Concerned fishermen, summer home owners, local ranchers and business owners formed the Henrys's Lake Foundation. The Foundation raised money and person power to help revitalize the lake fishery and dependent local economy.

The Foundation's most important role was to get fishermen, recreational property owners, business operators and lake-side ranchers working together toward common, mutually beneficial objectives for tributary riparian areas. The first tributary riparian restoration demonstration project was constructed in the fall of 1985 on Duck Creek. This is an important trout spawning and rearing stream. Riparian vegetation was severely deteriorated. Willows were drastically reduced in abundance. There was little regeneration due to constant grazing during their summer growth period. Streambanks were eroding. The stream channel was wide, shallow and full of sediment from trampled and eroded streambanks.

Henry's Lake:

The key to success was cooperation among fishermen, landowners and other businesses with a stake in restoring and maintaining the overall long-term economic productivity of the area.

Fishermen with a stake in improved riparian management were instrumental in overcoming traditional barriers between a Fish and Game Department and and agricultural interests. The key was their willingness to cost-share mutually beneficial solutions instead of simply blaming riparian land owners for the problem.

By forming a mutually beneficial partnership with the private landowner, the Henry's Lake Foundation avoided spending years and many thousands of its members dollars on studies to "prove" the obvious. Instead they invested their money and energy in implementing solutions which produced quick results instead of paper.

The Foundation raised money from its members to fence livestock from the riparian area along a half-mile reach of stream for a five-year recovery period. Foundation members took time off from jobs and vacations to build the riparian fence to the rancher's specifications. The Foundation paid the rancher a modest fee to cover the cost of maintaining the fence. Even after decades of impact from livestock grazing, loafing and trailing, the area fenced from livestock responded dramatically the first growing season.

Vegetation rapidly re-established on eroded streambanks and began the natural process of trapping sediments and narrowing and deepening the stream channel. The small amount of livestock forage forgone within the exclosure is thought to have been offset by denying livestock their preferred loafing area so they would spend more time eating the abundant irrigated forage outside the exclosure fence. This small pilot project demonstrated the value of fishery interests and livestock operators working together for mutual benefit. The spirit of cooperation proved to be contagious. It led to cooperative screening of irrigation diversions to prevent fish losses. The construction of additional riparian protection fences on this and other streams around the lake on private, state and federal land continued.

Three years into the pilot project on Duck Creek, the rancher, Foundation and Fish and Game Department cost-shared a pasture subdivision project which will provide increased livestock forage production and complete protection for the riparian area and stream channel.

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Oregon: Bear Creek

Bear Creek is located at 3,500 feet elevation in the high desert of central Oregon. Precipitation averages approximately 12 inches per year. Peak runoff normally occurs in mid to late February and summer thunderstorms are frequent. This site has been grazed by domestic livestock since the late 1800's. Prior to 1976 the riparian area was within a single pasture licensed for 72 animal unit months (AUMs). Under this grazing strategy streamside vegetation was low in diversity and productivity. Streambanks were actively eroding. The stream channel was deeply incised and contained medium to high sediment loads. Summer streamflow was often intermittent and low in quality.

In 1976-78, the area was rested from grazing to restore the productivity of the riparian area. In 1979 and 1980, the area was grazed for one week in September. From 1981 to 1984 it was not grazed. In 1983 juniper trees on adjacent uplands were thinned to improve livestock forage and watershed conditions. In 1985, the pasture containing the riparian area was divided into three pastures and grazed from the time of spring runoff (mid February) until April 15. Vegetation was allowed to regrow the rest of the year to protect streambanks against high runoff from summer thunderstorms and runoff the following spring. This regrowth also provided livestock forage for the following year. As a result, streambanks stabilized, reducing erosion and sediment production. This increased stability minimized stream channel damage from a major thunderstorm in 1987 that extensively damaged comparatively poor condition riparian areas immediately downstream. In some areas one to two feet of sediment from upstream were deposited within the restored riparian area.

The resulting improvement in water quality and general habitat conditions allowed rainbow trout to be re-established in this reach of Bear Creek. By 1989, the licensed amount of forage had increased to 354 AUM's, nearly five times the amount previously grazed from the area. The livestock permittee reportedly reduced his cost of supplemental hay by $10,000.

Bear Creek:

The principal management objective for the riverine-riparian area was to protect streambanks against erosion by high flows during spring runoff and during high-intensity summer thunderstorms.

The grazing strategy was designed to improve the riparian area by improving both riparian and upland vegetation.

By grazing pastures containing riparian areas early, livestock were less inclined to concentrate on riparian vegetation and better utilized adjacent upland forage.

Improvements in upland vegetation were required for full recovery of the riparian area and for the increase in livestock forage.

This early season riparian grazing strategy worked well on this site's sandy loam soils. It might not work as well or at all under different climatic or streamflow conditions. It also may not work on soils with high moisture content which are susceptible to shearing and compaction by livestock trampling.

Nevada: Mahogany Creek

The Mahogany Creek watershed lies at approximately 5,300 to 6,900 feet in elevation in northern Nevada. Precipitation in the case study area averages about 15 inches per year and comes mainly as snow melt. Peak runoff normally occurs in May and June. Mahogany Creek is approximately 11 miles long. The lower three miles of the stream flow through the Summit Lake Indian Reservation. Mahogany Creek is one of two areas in the U. S. where a lake-dwelling population of threatened Lahontan cutthroat trout reproduce naturally. Trout from Summit Lake annually migrate into Mohagony creek to spawn. The resulting juvenile fish migrate back to the lake to mature and eventually repeat the cycle.

The area has been grazed by livestock for at least 75 years. It was used heavily by both cattle and sheep from summer through fall. Improper grazing severely degraded the riparian area and surrounding uplands. The riparian area was virtually stripped of vegetation. Streambanks were badly eroded. Streamflows had declined and increased in temperature and sediment load. Spawning and rearing habitat for the threatened Lahontan cutthroat was severely degraded. In 1974 the BLM attempted to demonstrate riparian area restoration by simply reducing grazing in the allotment. However, even reduced grazing pressure prevented substantial recovery of the degraded riparian area. In addition, the agency was unable to prevent unauthorized grazing.

In 1976 the grazing permit for the allotment was relinquished by the permittee. The BLM used the opportunity to fence most of the creek and much of the watershed to exclude livestock. Riparian vegetation responded dramatically to rest from grazing. Installation of a few instream structures helped improve trout habitat by raising water levels and reducing erosion. Native perennial grasses increased throughout the exclosed area. Previously decadent aspen groves expanded. Curlleaf mountain mahogany began reproducing within the fenced area while outside the fenced area almost no seedlings survived the grazing.

Streambanks stabilized and erosion was reduced. The stream channel narrowed and deepened. Summer streamflow increased 400%, and depth of water increased 50%. Water temperatures and sediment load decreased. The improvement in fish habitat resulted in a significant increase in the threatened Lahontan cutthroat population.

Mahogany Creek:

Simply reducing the number of livestock in the allotment did not allow substantial recovery of the severely degraded riparian area and stream channel; livestock still overused the riparian area.

Even where riparian deterioration was severe and a threatened fish species was at stake, it was only after the grazing permit for the allotment was relinquished that the BLM was able to fence most of the creek and adjacent uplands.

Even under these long-standing, severely degraded conditions, ten years of rest resulted in dramatic improvement of riparian and upland vegetation. The quality and quantity of summer streamflow was increased.

Achieving similar improvements in the entire Mahogany Creek watershed would require a cooperative effort by numerous federal, tribal and private landowners and grazing permittees.

Texas: West Rocky Creek

West Rocky Creek is located at 1,800 feet elevation in the porous limestone of the Edwards Plateau. Annual rainfall averages about 18 inches. Peak runoff usually occurs in late spring and fall as a result of thunderstorms. Prior to the introduction of livestock in the mid 1800's, the watershed landscape was dominated by native grasses characteristic of the southern Great Plains. The U. S. Soil Conservation Service estimates vegetation was comprised of 95% grasses, 10% forbs and 5% woody plants. Trees and brush were largely confined to riparian corridors due to thick prairie turf and periodic fires which limited seedling survival on the uplands.

West Rocky Creek:

The dramatic decline in the productivity of the West Rocky Creek watershed resulted in largest part from poor livestock grazing practices, notably continuous, year-long, heavy grazing.

Extensive, costly upland brush removal and grass reseeding were required in addition to improved grazing practices in order to repair the damaged watershed and restore streamflows and riparian areas.

Proper grazing management is essential to maintain the improved condition and protect the substantial investment in restoring the watershed's productivity.

Restoring diverse, more productive upland and riparian plant communities benefitted livestock, fish and wildlife, and downstream water users.

Technical assistance with private and public cost-sharing were essential to finance high cost watershed improvements. The economic and environmental benefits extended far beyond the private lands that were restored in productivity.

Native grasses such as sideoats grama, buffalo-grass, curly mesquite and tobosa, shielded the soil from the sun and from wind and water erosion. Dense root systems allowed rainfall to soak into the soil to recharge groundwater and keep streams flowing year-long. Early ranchers didn't understand range ecology and lacked experience in this environment necessary to predict the effects of overgrazing. By 1885, vegetation within the watershed had been dramatically altered by livestock overgrazing. Removal of the native grasses decreased infiltration of water into the soil. The invading brush lowered water tables, accelerated runoff and soil erosion. Man's fire suppression activities allowed brush to establish.

Dense stands of mesquite and juniper began to dominate the landscape. These deeper-rooted plants used groundwater below the depth grasses could reach. This depleted water that previously had recharged springs and streams. West Rocky Creek, which once flowed year-round, became intermittent in 1918, and dried up completely in the 1930's. The stream flowed sporadically during periods of above average rainfall. Without the protective cover of grasses, flooding and stream channel erosion increased.

In the early 1960's, five ranchers began a range rehabilitation program with technical assistance and cost-sharing under the Great Plains Conservation Program. They removed brush, reseeded grasses and implemented a variety of improved grazing strategies on about half the 74,000-acre watershed. Livestock forage increased. Soil erosion and sedimentation of downstream municipal water supply reservoirs decreased. By 1970, springs that had been dry for decades began to flow again on all five ranches. West Rocky Creek began to flow year-around, yielding from 150 gpm during the severe 1984 drought up to 4,000 gpm. Riparian vegetation re-established. Streambanks and the stream channel stabilized. Fish and riparian dependent wildlife re-established.

Improving the productivity of the West Rocky Creek watershed produced significant downstream economic benefits to the city of San Angelo. The quantity and quality of water yielded to water supply reservoirs increased. Reduced sedimentation increased the economic life of reservoirs and decreased water treatment costs. Flooding reduced in severity.

Utah: Big Creek

Big Creek rises from springs at about 8,000 feet elevation in the northeast corner of Utah. Elevation in the case study area is about 6,600 feet. Precipitation averages about 17 inches per year and comes mainly as snow. Peak runoff normally occurs in May or early June. The stream heads in federal lands and ends in private lands.

The area traditionally has been grazed annually continuously from May through October. Consequently, riparian vegetation, streambanks and water quality were severely degraded. In the late 1960's the BLM proposed a 1.5 mile riparian improvement project. The objective was to improve fish habitat and overall riparian conditions, and to demonstrate for livestock operators the rate of recovery and vegetative potential of the riparian area. The proposal was resisted by local livestock interests and the area temporarily fenced off from livestock was reduced to 0.5 mile of stream. Fish habitat improvement structures were placed in the stream within and outside the exclosed area in 1970 and 1971.

Despite occasional unauthorized grazing within the fenced area, riparian vegetation and the stream responded dramatically to rest from grazing. Streambanks became more stable. The stream narrowed and deepened. The riparian area widened due to the raised water table. However, fish habitat improvements within the fenced area were counteracted by poor watershed conditions upstream. Instream structures trapped large amounts of sediment from upstream erosion. Instream structures outside the exclosure ceased to function and were washed out because of unstable streambanks caused by poor grazing management.

The deteriorated condition of the watershed and results of the sixteen-year demonstration/research project led to recommendations for short-term reductions in grazing and changes in the grazing strategy for the allotment. These recommendations were not implemented. Riparian areas outside the exclosure continued to be heavily grazed season-long.

Big Creek:

It was difficult to implement a small demonstration project on this public land site, even though riparian areas and the stream were severely deteriorated.

Sixteen years of research and demonstrated success at improving riparian, stream and grazing conditions were inadequate to overcome resistance to changing the grazing strategy on this allotment.

Unauthorized grazing inside the fence was a problem because the permittee was not a cooperator in the demonstration project.

Some riparian and stream management objectives were not achievable because the watershed upstream remained in poor condition due to poor grazing management.

South Dakota: Bad River

The Bad River, a 3,152 square mile basin is representative of the Northern Shale Plains which covers about 67 million acres in the Northern Great Plains. Annual precipitation averages about 15 inches with about 80% occurring between April and September. Peak rainfall months are May and June, but intense thunderstorms are common throughout the summer months. Introduction of domestic livestock and improper grazing practices accelerated sheet, rill, and gully erosion within the drainage. Over-grazing and livestock trailing to water activated gully erosion and increased runoff from steep, weakly-developed upland soils.

Overgrazing of native grasses reduced water infiltration into the soil and exposed the soil surface to the erosive force of accelerated overland runoff. The increased rate of runoff eroded and down-cut gullies and stream channels weakened by livestock trailing and trampling and removal of riparian vegetation. These conditions intensify the naturally extreme seasonal variations in runoff. Since 1928 Bad River flows ranged from 0 to 4,290 cfs. Exposed upland and riparian soils produce prodigious amounts of sediment and bedload material which are transported out of the Bad River Basin and eventually into the Missouri River. During one extreme event on May 14, 1982, Bad River discharged 949,300 tons of sediment. On the average, each square mile of the basin annually produces 1,418 tons of sediment and bedload material.

Bad River:

Cross fencing and off-stream water developments are important tools to reduce overgrazing and trailing impacts on vulnerable riparian and drainage areas.

Multiple pastures and rest-rotation grazing strategies allow riparian areas to be protected when they are most vulnerable to livestock damage.

Restoring and protecting riparian areas requires decreasing the rate of runoff from uplands, restoring riparian vegetation, and protecting streambanks from livestock during vulnerable periods.

The adverse effects of accelerated erosion and runoff due to improper grazing in the Bad River drainage are felt far beyond the drainage.

Erosion in the Bad River drainage has far-reaching adverse effects. Bad River sediment deposits in the Missouri River restrict the channel. Resulting ice buildups reduce the water release capacity of Oahe Dam. This, in turn, results in reduced generation of electricity and periodic flooding of portions of the city of Pierre. The poor condition of the Bad River watershed also adversely affects fishing in the Missouri River which is important to the Pierre-Fort Pierre area economy. Bad River sediment deposits reduce fish production by smothering eggs. In addition, for six to eight weeks following major runoffs, suspended sediments from Bad River muddy water and greatly reduce fishing success in twenty to thirty miles of the Missouri River.

Improved grazing strategies can significantly reduce erosion in the Bad River drainage. Moderate and flexible stocking rates are essential due to the wide fluctuations in timing and amounts of annual precipitation. Cross fencing and stock water development can improve livestock distribution, provide better control of grazing intensity, and take pressure off riparian areas by changing grazing patterns and reducing trailing. Various rest-rotation grazing strategies can keep livestock off streambanks and other fragile areas during the times they are most vulnerable to damage.

Idaho: Sand Creek

Sand Creek is located in southwestern Idaho at 2,200 feet elevation. Annual precipitation is about 9 inches and comes mainly as snow and spring and fall rain. In the early 1930's this site was cleared and leveled to flood irrigate 170 acres of pasture. In recent years about 125 cows, 3 to 4 bulls and their offspring were grazed year-round. Portions of the area were grazed for short periods and then devoted to producing hay for winter feed.

Dirt-formed irrigation and drain ditches and streambanks were trampled and eroding. Ditch maintenance was a major operating cost. Significant amounts of sediment were contributed to Sand Creek. In late 1987 the property was sold. The new owner set a goal of maximizing profit. Protection of riparian areas or reducing nonpoint source pollution were not planning considerations. With the traditional pasture configuration and season-long continuous grazing, livestock could not be economically managed to optimize forage production. Neither could the riparian areas be protected and irrigation ditches would continue to produce sediment to drainage ways.

The operator was convinced that both profits and environmental conditions could be enhanced at the same time by putting the properties under a good grazing management plan. The 170 acres were divided into 15 pastures and grazed April-October by a single herd of 600 yearling steers. Fences blocked livestock from Sand Creek and all dirt drain and irrigation ditches. Stock water was piped to troughs. The grazing strategy was designed to meet the physiological needs of the dense stand of fescue, and thereby maximize forage production. Plants were allowed to reach Soil Conservation Service-recommended height before animals were turned in. High animal density encouraged uniform forage utilization. When the recommended minimum stubble height was achieved, animals were moved to the next pasture.

Sand Creek:

Achieving the long-term benefits of restored riparian areas and reduced nonpoint source water pollution was compatible with short-term profits.

Meeting the physiological needs of the forage plants was the key to maximum profit.

This grazing strategy obtained dramatic, profitable results by applying centuries-old grazing concepts and commonly available guidelines and technical assistance.

Grazed pastures received the SCS-recommended amount of rest for regrowth before livestock were reintroduced. The recommended minimum stubble height was maintained late in the growing season to encourage storage of energy for forage production the following spring. The grazing strategy more than doubled the pounds of beef traditionally produced on this property. The cost of grazing improvements was recovered during the first year of operation. Fencing livestock out of dirt irrigation and drain ditches reduced operating costs and production of sediment. Denying livestock access to streambank loafing areas reduced erosion. Streambank vegetation fenced off from livestock provides excellent habitat for waterfowl, upland game birds and other wildlife, and filters irrigation water running off pastures.

Wyoming: Huff Creek

Huff Creek is located at 6,600 feet elevation in the mountain foothills of southwestern Wyoming. Precipitation averages about 16 inches per year and comes mainly as snow. Peak runoff normally occurs in April or May. Huff Creek is one of several streams within a 91,000 acre multiple-permittee allotment. Prior to livestock grazing the riparian area probably was dominated by sedges, rushes and willows. The area was predominately grazed by sheep from the late 1800's until the late 1960's when most permittees converted to cow/calf operations. This conversion prompted aerial spraying with herbicides to kill upland and riparian shrubs and increase grass for continuous May through September grazing.

Herbicides and intensive grazing eliminated riparian willows and consequently, beavers. The water table dropped and streambanks eroded. The riparian area shrank and was invaded by sagebrush and rabbitbrush. Stream water temperatures and silt load increased. Once a popular cutthroat trout fishery, the Wyoming Game and Fish Department estimated Huff Creek's trout population declined from 222 fish per mile in 1958 to 36 per mile by 1978.

In the mid-1970s the trout in Huff Creek were identified as a pure strain of Bonneville cutthroat trout, then under consideration for listing as a threatened species. To provide the fish emergency protection in 1976 and 1979 livestock were excluded from two stream reaches totaling about one mile in length. Instream structures and rock rip-rap were installed to elevate the water table, improve trout habitat and reduce streambank erosion.

The area inside the fences responded dramatically. Streambanks healed. The stream channel narrowed and deepened. Within five years the riparian area had roughly doubled in width due to the elevated water table. Vegetation shifted from sagebrush and rabbitbrush back to grass. Grass inside the fences was dense and over two feet high. One stockman remarked he had never seen anything like it in that area. Grass outside the fence was sparse, less than two inches tall, and dominated by sagebrush.

The demonstrated potential for increasing livestock forage while simultaneously protecting other riparian values prompted the livestock association to change the grazing strategy for the six mile long drainage. A rider was hired to herd stock in the north half of the allotment. Grazing in the Huff Creek valley bottom was delayed until late August through September. The lower half of the valley received light grazing because the herding accelerated the animals natural drift pattern.

Herding and strategically placed salt blocks improved livestock distribution and provided ungrazed forage for stock being trailed to winter pastures. The number of calves and weight gains improved. In three years riparian vegetation outside the fence looked the same as vegetation inside the fence. Huff Creek had narrowed by about one-third, doubled in depth, and water temperatures had declined. The percentage of eroding streambanks decreased from about 80% to 20%. The number of Bonneville cutthroat trout increased to 444 per mile, a 1,100% increase over 1978 levels.

The success of Huff Creek and similar efforts elsewhere removed the immediate threat to survival of the Bonneville cutthroat. In 1987 the U. S. Fish and Wildlife Service decided to wait until 1992 to review the results of habitat recovery projects before deciding whether to proceed with listing the fish as a threatened species.

Huff Creek:

Herding livestock to fresh forage, and providing the grazed forage proper rest for regrowth, is an ancient art form that still works. Animal weight gains improved concurrently with improved riparian conditions.

Steep terrain and natural barriers facilitated herding by restricting livestock movement between drainages.

Herding was successful at keeping cattle out of a drainage; it was not successful at keeping cattle out of the riparian area once they were in the drainage.

Herding was as effective as fences in controlling livestock grazing of riparian areas.

The effective rider clearly understood the objective of the riparian improvement grazing strategy and was dedicated to the project and worked the cattle daily.

The area had been in a deteriorated condition for so long local stockmen were surprised by the vegetative potential revealed by improved grazing management.

Idaho: Henry's Fork

The Henry's Fork River drains a 4,000 square mile area in eastern Idaho on the west side of Yellowstone National Park. The study site elevation is about 6,200 feet. Annual precipitation averages approximately 45 inches which comes mainly as snow and to a lesser extent from summer thunderstorms. The river is fed by numerous large springs; Big Springs alone discharges approximately 0.5 million gallons per day. The spring water provides excellent growing conditions for rainbow trout which attract anglers from all over the world. The spring water keeps much of the river from freezing, thereby providing good winter conditions for fish and wildlife, including the threatened trumpeter swan.

Bison, antelope, moose, elk and deer grazed the watershed for thousands of years. Cattle and sheep have grazed the area since the late 1800's, numbering more than 3 million animals in their heyday. In the 1960's and mid 1970's the 12,700 acre Railroad Ranch -- famed world-wide in trout fishing circles -- was donated to the State of Idaho. Forty seven hundred acres became the Harriman State Park. An adjacent 1,000 acres, called the Harriman East, are managed by the Idaho Foundation for Parks and Lands. Together they encompass six miles of some of the best rainbow trout habitat in the U.S.

Deeds transferring the property contained strong covenants to protect the environment. Livestock numbers were drastically reduced on Harriman East. Nonetheless, mid June to mid October continuous season-long grazing still resulted in poor utilization of upland forage, damage to riparian vegetation and streambanks, and increasing conflict with growing numbers of fishermen. In 1984 the single pasture was divided into four pastures, one of which was a narrow "set-back" pasture parallel to both sides of the river. This pasture included more land area than a typical stream corridor exclosure, but less area than normally would be included in a riparian pasture.

Livestock were grazed under a stuttered deferred rotation strategy. The set-back pasture will not be grazed until riparian and streambank recovery objectives are met. Then it will be grazed under special prescription. Implementing this grazing strategy allowed the livestock permittee to continue grazing the same number of animals to start, and increase animal numbers by 25% in the fourth year of operation, despite two consecutive years of drought. The non-profit Park Foundation continued to get badly needed grazing revenue. The set-back pasture eliminated fishermen-livestock conflict, and allowed future livestock use of streambanks to be carefully controlled to protect fish and wildlife habitat.

The adjacent area now within the 4,700 acre Harriman State Park traditionally was grazed June-October by large numbers of livestock. After the park was formed, grazing was restricted to approximately 2,500 acres. The grazing period was limited to a few weeks in late fall to eliminate conflicts with spring waterfowl nesting and brood rearing in the riparian area and adjacent uplands, and to eliminate summer livestock conflicts with growing numbers of fishermen.

The grazing strategy accomplished its objectives by forgoing the majority of the area's livestock forage potential. However, it had the unintended consequence of concentrating livestock on Henry's Fork streambanks. By late fall upland grasses are mature and dormant. Livestock naturally are attracted to the green vegetation in the riparian area. Streambank vegetation was overgrazed and banks were trampled which degraded important shore-line trout habitat. This eventually led to increasing complaints from the public that livestock grazing was not compatible with the park's mandate to protect the high quality Henry's Fork trout fishery.

In 1988 the Henry's Fork Foundation, a private organization of fishermen, local businessmen and property owners, proposed to cost-share with the State of Idaho a solution to livestock/fishery conflicts on the park. Within a few months a plan was developed, approved, funded and implemented. Both sides of the Henry's Fork River were fenced to exclude livestock from streambanks; alternative stock water was available. The fence was strategically located far enough back from the river to provide generous area for waterfowl nesting and brood rearing, and abundant cover from predators. Additional design considerations included providing adequate loafing area for fishermen, birders and picnickers, and minimizing visual obtrusiveness of the fence from the river.

The fence eliminated all sources of conflict that had severely limited and threatened to end livestock grazing on the park. It provided park managers the option of capitalizing on the significant revenue potential of increasing grazing on virtually all of the 2,500 acres available to livestock.

Henry's Fork:

Drastically reducing both the number of livestock and the grazing season were not sufficient to achieve riparian management objectives on Harriman State Park.

Innovative, practical solutions were possible even when extremely high riparian and stream resource values appeared to be irreconcilable with livestock grazing. Because there were no governmental bureaucracies involved in the Harriman East allotment, decisions and solutions to problems were implemented immediately.

Private and public cost-sharing and win-win solutions facilitated quick, efficient riparian protection. On the Harriman East site, the solution was devised and implemented almost immediately due to cooperation of the livestock grazing permittee.

Livestock grazing on these park lands almost certainly would have been eliminated if riparian conflicts had not been speedily resolved. The solutions not only maintained livestock grazing, but allowed it to increase. Nonetheless, some livestock interests strenuously opposed fencing to protect Henry's Fork streambanks from the effects of livestock grazing.

Oregon: Horse Heaven Creek

Elevations in this central Oregon case study range from 3,600 to 4,500 feet. Annual precipitation ranges from 9 inches in the lower areas to 15 inches in the higher elevations. This area has been grazed by domestic livestock for more than a century. In this case study the rancher runs a cow/calf operation on 43,000 acres of private and public land. The rancher cleared over 6,000 acres of juniper on his private land to improve upland range conditions by encouraging native grasses. Before and after studies showed treated areas improved from 19 acres per AUM to 2.7 acres per AUM. In spite of improved upland conditions, the rancher was still concerned about his livestock "....lying on the creeks and starving to death." His cattle tended to concentrate on and overgraze riparian areas and under-utilize abundant upland forage.

To solve this problem, he fenced over six miles of Horse Heaven Creek into separate pastures. They were rested from grazing for a three-year recovery period, then grazed under a high intensity short-duration spring grazing strategy. At the rancher's request, the U.S. Forest Service also fenced the stream on his allotment upstream, which is grazed in the same manner. The rancher's cattle now graze the uplands more uniformly. The riparian areas and creek have improved dramatically.

The combination of improved upland and riparian vegetation have reduced erosion and improved streamflows. Streams that used to go dry in some years now flow in years with half as much precipitation. Improvements in upland and riparian vegetation allowed the rancher to increase his cow/calf numbers by 50% and improve the average weaning weights of calves by 150 pounds. Improved riparian conditions attracted more elk and beaver. According to this successful rancher, "the best environment for raising cattle is also the best environment for wildlife. He considers beaver a positive influence on watershed recovery. "I wish I had more of the irrigating SOB's." He credits good diversity in upland and riparian vegetation with providing more stability to his livestock operation, especially during dramatic variations in weather patterns. His ranching philosophy is "The closer that you can have it like nature the better off you are in the long run. It's more economically sound."

Horse Heaven Creek:

Despite availability of abundant upland forage, cattle tended to concentrate in and overuse riparian areas.

Fencing riparian areas into separate pastures allowed the rancher to obtain utilization of upland and riparian forage and improve watershed conditions.

Improved management of upland and riparian vegetation combined to reduce erosion and sedimentation of streams and irrigation and fishing reservoirs, and to enhance summer streamflows.

Improved riparian vegetation encouraged beaver activity which raised stream water levels and expanded the riparian zone. This increased livestock forage and wildlife habitat and decreased erosion and sedimentation.

Good riparian management was an integral part of increasing the ranch's long-term productivity and profitability.

METHODS

COWFISH HABITAT MODEL

INTRODUCTION

The COWFISH Model was designed to provide a tool for range and aquatic specialists to assess the effects of range management on stream salmonid populations. The model was developed by the U.S. Forest Service's Northern Region, Wildlife and Fish Division. Copies of Lloyd's (1986) COWFISH manual are available from USDA Forest Service, Federal Building, P.O. Box 7669, Missoula, MT 59807; phone 406/329-3101.

The objectives of the model were to estimate the degree of grazing compatibility existing with the associated aquatic resources, identify what livestock management may be doing to the fishery, and develop sensitivity in livestock managers to stream/riparian habitat degradation.

Unfortunately the model uses qualitative data to estimate quantitative-type results based on fish-habitat relationships that were developed by intuition and speculation and not from empirical data. The concepts and assumptions used to develop the model were not tested or described. In short, many of the basic ground rules of model development were violated.

Testing of COWFISH by Shepard (1989), and Contor and Platts (in Press) found that COWFISH could roughly predict the abundance of rainbow and cutthroat trout in the streams of central Montana and brown trout in one stream in Utah, but for brook trout in central Montana and all trout in other streams examined in Idaho, Nevada, and Utah, it could not predict trout abundance.

The utility of COWFISH for predicting trout abundance is questionable, but the model may be useful in estimating relative stream/riparian health. For land managers responsible for stream/riparian habitat, and not trout population management, trout abundance may not be as important as habitat quality. Managers may find COWFISH most useful if they calculate only the habitat suitability index (HSI) and ignore the fish abundance and economic loss estimations.

The variables used in COWFISH probably relate to trout abundance but, apparently, too many other factors are not accounted for. However, in terms of water quality, bank and channel stability, and some desirable traits of fish habitat, COWFISH does examine several useful variables. Conceptually, a stream with a low habitat suitability index (HSI) would be more degraded and susceptible to damage during extreme flow events than a stream with a high HSI.

MANAGERS MAY FIND COWFISH MOST USEFUL IF THEY CALCULATE ONLY THE HABITAT SUITABILITY INDEX (HSI) AND IGNORE THE FISH ABUNDANCE AND ECONOMIC LOSS ESTIMATIONS

Beginning on p. IV-13 there is a user's guide to the PC program on diskette (Appendix E). Some sample data forms are included at the end of this section.

Model Description

Concept and Development

The model is patterned after the U.S. Fish and Wildlife Service's Habitat Suitability Index (HSI) model, constructed by their Western Energy and Land Use Team. COWFISH is listed as a working model by the United States Environmental Protection Agency (EPA 1987) in their Guide to Nonpoint Source Pollution Control. The EPA (1987) and Lloyd (1986) concluded that COWFISH was designed for Montana conditions, but, with adjustments, it was usable throughout the western United States. Neither document identifies what adjustments would be needed for such extrapolation.

The model is based on the concept that habitat suitability for trout increases as favorable attributes become more prevalent. Five habitat attributes are averaged to make an HSI, which is assumed to be roughly proportional to trout abundance. The HSI is then tempered by stream width, stream width to depth ratio, stream gradient, and parent rock material to estimate optimum and existing fish abundance.

The difference between the estimated optimum and the estimated existing number of trout becomes the number of fish lost. It is assumed that the number of fish lost is a result of the impacts of livestock on the stream/riparian habitat. Economic loss is calculated by multiplying each fish lost by \$10.65, which is based on an estimate that a wildlife-fisherman user day (WFUD) = \$63.87 and six fish are caught per WFUD (USDA 1985).

Capabilities And Limitations Of Cowfish

The published capabilities and limitations of the COWFISH model can be summarized from the EPA (1987) document and Lloyd's (1986) paper as follows: COWFISH can estimate fish abundance in streams anytime that snow is not on the ground; however, data should be collected just after the grazing season; the model is best suited to low gradient, meadow type streams; COWFISH is less suited to streams with gradients steeper than 5%, widths wider than 18 feet, and banks dominated by rock and rubble.

We suggest that the capabilities of COWFISH are limited to a qualitative look at stream/riparian habitat health, and that estimations of fish abundance, fish loss, and economic loss are beyond its capabilities except in serendipitous situations. COWFISH can satisfactorily generate an index for stream/riparian health, but it gives no indication of how management should respond to low or high HSI values. It is unknown if low HSI values indicate that a stream system is at risk for head cutting or "blowing out."

THE MODEL IS BEST SUITED TO LOW GRADIENT, MEADOW TYPE STREAMS

Assumptions

Assumptions of the model, either stated or implied, include:

a. Fish populations are dependent upon or correlated with those physical habitat features that COWFISH estimates;

b. Fish populations are sufficiently independent of prior years, conditions up- and down-stream, other species, and intrinsic population dynamics;

c. Users will estimate stream-riparian attributes with sufficient accuracy and precision;

d. The variables and procedures used to calculate economic values are reliable; and

e. Minor violations of the above assumptions do not render the model useless.

Input and Working Variables

Eight environmental attributes are estimated, by eye, for the input variables. The variables are used to estimate the habitat suitability of a stream for trout. Each variable will be discussed in detail below; they are summarized as follows:

1. Percent of the bank that is undercut;

2. Percent of the bank with overhanging vegetation;

3. Percent of the bank with exposed soil or with vegetation that has been trampled by livestock (termed alteration);

4. Percent substrate embeddedness;

5. Stream width/depth ratio;

6. Stream width;

7. Stream gradient;

8. Parent rock type (granitic or non-granitic).

Five additional variables are used in conjunction with the above estimates to calculate trout abundance, trout loss, recreation loss, and the economic value of trout lost.

9. Optimum stream width;

10. HSI (or also mean parameter suitability index; PSI);

11. The length of the reach being evaluated;

12. One Wildlife-Fishery User day (WFUD) equals $63.87;

13. The capture of 6 catchable-size trout equals one WFUD.

The variables "1-5" in the above outline are converted to suitability indexes called parameter suitability indexes (PSI) which are derived from fixed non-linear relationships that were developed by intuition and speculation. For example, percent undercut is called PSI-1 and is determined by matching the percent occurrence of undercut banks with the appropriate PSI-1 index found in Table 1 (i.e. 45% undercut banks would give a PSI-1 rating of 0.6). PSI-1 through PSI-5 are averaged together to give the mean PSI which is the HSI estimate.

Percent Undercut Bank

Percent undercut bank is simply the percent of the streambanks in the sample area with bank angles of less than 90 degrees. Thirty feet of undercut bank on a 100 ft. section of bank would be 30%. This appears straight forward; however some difficulties exist. Thirty percent of the banks on a stream could be very stable, well rooted, undercut 1 ft., with a water depth of 2 ft. under the bank; while 30% of the banks on another stream could be very unstable, undercut 1 in., with only 2 in. of water under the bank. COW-FISH would rate both streams the same in terms of the suitability of the undercut banks for trout.

The given relationship between percent bank undercut and trout habitat suitability rating is almost a straight line (Table IV-1). When 85% or more of the streambanks are undercut, the habitat suitability index indicates optimal conditions (in terms of undercut). In some riverine-riparian types, the stream may experience severe stability problems at that state. Undercut banks can vary tremendously in stability depending on soils, vegetation, and other factors.

Table IV-1. Relationship between undercut banks and the PSI rating.

Undercut Bank (Percent)	PSI - 1
85	1.0
75	.9
60	.8
50	.7
45	.6
40	.5
35	.4
30	.3
25	.2
10	.1
0	0.0

Overhanging Vegetation

The measurement of overhanging vegetation is very similar to that of undercut banks. A person simply measures the percent of the bank, parallel to the stream, that has vegetation hanging over the water. The same difficulties exist with estimates of overhanging vegetation as with undercut banks. Vegetation overhanging the entire channel is recorded the same as vegetation overhanging several inches on each side. It is unclear if overhanging vegetation 200 ft. above the water should be counted. While a reasonable cutoff level may be at 2 or 3 ft., vegetation 10 feet over the stream may be important for shade (Platts and Nelson, in press). If the water column were completely covered by vegetation, the habitat suitability rating for trout would be at its highest. The validity of this relationship is questionable (Table IV-2).

Table IV-2. Relationship between vegetation overhang and the PSI rating.

Vegetation Overhang (Percent)	PSI - 2
100	1.0
7	.9
55	.8
45	.7
40	.6
35	.5
25	.4
20	.3
10	.2
5**	.1
0	0.0

** We changed this from Lloyd's (1986) paper from 0 to 5. It didn't make sense to have 0% vegetation overhang equal to two PSI values.

Streambank Alteration

Streambank alteration is defined as the percent of the bank that has exposed soils or has vegetation that was trampled by livestock. The percent streambank alteration has a curvilinear relationship with its selected PSI value (Table IV-3). Fifty percent of the streambanks can be altered and the habitat suitability will remain near optimum; this is probably an erroneous concept. The relationship between streambank alteration, as defined by COWFISH, and trout habitat suitability needs to be tested and re-evaluated.

Table IV-3. Relationship between streambank alteration and PSI rating.

Streambank Altered (Percent)	PSI - 3
0	1.0
15	.9
30	.8
35	.7
40	.6
45	.5
50	.4
65	.3
80	.2
90	.1
100	0.0

Embeddedness

Percent substrate embeddedness is defined as the percent of larger substrate particles that are enveloped by silts and sands. Sand and silt bottoms are considered to be 100% embedded. Embeddedness of 70% would indicate that the majority of the gravel and cobble of a streambed has sand and/or silt occluding the interstitial spaces between individual rocks such that only 30% of a rock protrudes above the fine sediments.

As percent substrate embeddedness increases, the PSI curve indicates that habitat suitability decreases (Table IV-4). While this may be correct is some systems, Platts (1974) studied 39 tributaries of the South Fork Salmon River and found that, as fine sediments in the channels increased spatially, fish populations increased. Apparently this relationship occurred because other factors favoring salmonids increased as fine sediments increased.

Platts and Nelson (in preparation) tested 45 streams in the Northern Rocky Mountains, Great Basin, and Wyoming Basin ecoregions, and found that embeddedness was not significantly related to fish standing crops.

The embeddedness--habitat suitability relationship includes the concepts that 0% embeddedness is optimum and that embeddedness over 55% is completely unsuitable. The fact that numerous study sites with high densities of trout have substrate embeddedness estimates over 75% suggests that the proposed relationship is probably erroneous for many systems.

Table IV-4. Relationship between channel substrate embeddedness and selected PSI ratings.

Embeddedness (Percent)	PSI - 4
0	1.0
10	.9
20	.8
25	.7
30	.6
35	.5
40	.4
43	.3
46	.2
50	.1
55	0.0

Stream Width-Depth Ratio

Stream width to depth ratio is simply the mean stream width divided by the mean depth. COWFISH uses the concept that the wider and shallower a stream is, the less productive the fishery is. Only streams with a width-depth ratio less than five are considered optimum (Table IV-5). While this relationship may be true for some streams, many of the most productive streams in North America have a width-depth ratio so high that they wouldn't even appear in Table IV-5 (see Table IV-6).

When COWFISH was developed, the assumption was made that if the width-depth ratio was 15 or more then the stream channel's ability to contain peak flows was decreased dramatically and excessive erosion may result (from USDA, 1975). Actually, when flood flows are spread over a broad flood plane, hydraulic forces are dissipated and the potential for channel and bank erosion is reduced. Furthermore, streams with low and high width-depth ratios can be found within confined or unconfined floodplains.

The basic concept used in estimating the habitat suitability of streams based on width-depth ratios needs serious analysis. The method doesn't identify reaches that are at risk to down-cutting and major erosion. It also penalizes our most productive streams and rivers as being poor fish producers: the Kenai River in Alaska has a width-depth ratio of 75; the Henry's Fork in Idaho, 133; Silver creek in Idaho, 54; and the Yellowstone River in Wyoming is 85.

The model was designed to be used mainly on streams less than 18 feet in width, and it is probably better suited for small streams, but this hasn't been tested for confirmation.

Table IV-5. Relationships between the stream width-depth ratio and selected PSI rating.

Width-Depth (Ratio)	PSI - 5
<5	1.0
6	.9
13	.8
19	.7
20	.6
21	.5
23	.4
25	.3
26	.2
> 26	.1

Table IV-6. Width-depth ratios of selected streams containing high fish standing crops.

Stream/Location		Ratio
Kenai River, AK		54
Silver Creek, ID	(Nature Conservancy)	54
Henry's Fork, ID	Harriman State Park	133
Portneuf River, ID	Inkom	64
Yellowstone R.	Hayden Valley	85

Using COWFISH: Model Mechanics

The evaluator must design the study to be suitable for the site. The success of the evaluation depends on the sample design, accuracy of the ocular estimates, and the validity of the assumptions of the model for the site.

An appropriate sample design might include 3-5 sampling areas. Each area would be composed of 5-10 twenty-foot sections of stream. Each area and section could be located by a simple stratified-random method. In each section the evaluator would estimate the percent of the banks (on both sides) that had undercut banks, overhanging vegetation, and streambank alteration. Stream width, stream depth, and substrate embeddedness could be measured at the top, middle and bottom of each twenty-foot section.

This type of sampling strategy would provide an n-size of 15 to 50 estimates of percent occurrence of undercut banks, overhang vegetation and bank alteration, as well as 45 or more estimates of embeddedness, stream width, and stream depth.

Calculating the Habitat Suitability Index

A mean value is computed for each attribute and given a PSI rating depending on the relationships in Tables IV-1 to IV-5. If the average occurrence of undercut banks from all sections was 45% then the PSI-1 value would be 0.6 (Table IV-1). To calculate the HSI value, all five PSI values are averaged together.

$$\text{Mean PSI} = \frac{\text{PSI-1} + \text{PSI-2} + \text{PSI-3} + \text{PSI-4} + \text{PSI-5}}{5}$$

The mean PSI is the HSI estimate (Table IV-7). An HSI value of 60% indicates that the habitat suitability for trout is at 60% of its optimum. Table IV-8 provides an overview of the steps taken and calculations made when working through COWFISH.

Table IV-7. Determining the percent of the optimum habitat suitability for trout.

PSI (Mean)	Optimum Habitat Suitability (Percent)	
1.0	100	Excellent
.9	90	
.8	80	Good
.7	70	
.6	60	Fair
.5	50	
.4	40	
.3	30	Poor
.2	20	
.1	10	
0.0	0	

Optimum Stream Width

Optimum stream width is calculated by multiplying the existing stream width by the PSI-5 value (PSI for stream width to depth ratio). If the PSI-5 is less than 0.5 then use 0.5.

Optimum Trout Abundance

Optimum trout abundance is estimated by multiplying the optimum stream width by the appropriate coefficient listed below, depending on the gradient and drainage type. Stream gradient is in percent, 100 x (rise/run).

Use:
0.75 for granitic drainages, stream gradients > 5.0;
1.50 for granitic drainages, stream gradients < 5.0;
2.00 for non-granitic drainages, stream gradients > 5.0;
5.00 for non-granitic drainages, stream gradients < 5.0.

The estimate of optimum trout abundance is in terms of the number of catchable trout (trout over 6 inches) per 984 ft. of stream. All COWFISH estimates are per a 984-ft. section of stream. Users will have to convert the estimates to meaningful units depending on the situation. If COWFISH can reasonably predict the number of trout in a stream, the above coefficients may need to be altered. Using or changing the above coefficients is meaningless if there is no relationship between actual trout abundance and COWFISH estimates.

Existing Trout Abundance

Existing trout abundance is estimated by multiplying the estimate for optimum trout abundance by the mean PSI (or the decimal equivalent of the HSI). If the mean PSI were 0.75 and the estimate for optimum trout were 100 trout/984 ft., then the estimate for existing trout would be 75 fish/984 ft. of stream.

Trout Loss

Trout loss is simply the difference between the estimates for the optimum and existing number of trout (100 trout/984 ft. - 75 trout/984 ft. = 25 trout loss/984 ft. of stream).

Recreation Loss

Trout loss/984 ft. divided by 6 is recreation loss/984 ft. of stream. This is based on the estimate that six fish are caught during each Wildlife and Fish User Day (WFUD; USDA 1985).

Economic Loss

Economic loss/984 ft./year of stream is calculated by multiplying the estimate of recreation loss by $63.87. One WFUD equals $64.87; COWFISH cites USDA (1985).

Interpretation Of Results

Caution must be used when interpreting the results of COWFISH. This guide points out some of the current problems of COWFISH to prevent its misuse. During the general use of COWFISH, critical assumptions of the model will be violated. We suggest that you don't use the estimates of fish abundance or economic loss unless you have determined that COWFISH satisfactorily predicts fish abundance in your system. Prior testing (Shepard 1989; Contor and Platts, in prep.) has shown that COWFISH, at best, is a rough estimator for trout abundance and that it can be very misleading. It is probably appropriate to use the estimate of HSI as a general guide and index to riverine-riparian health. Beyond that, too many assumptions are being violated for COW-

FISH to work. The model estimates abundance only for salmonids greater than 6 inches. Conceptually then, it has little application for evaluating systems that rear anadromous or adfluvial salmonids. However, this may not be important because COWFISH can't reliably estimate fish abundance anyway. Using the HSI might be as useful in streams with catchable sized trout as those without.

The model is crude at this stage of development and should be used cautiously and with the aid of professional judgment. The model is apparently confounded by the natural variability of riverine-riparian complexes, natural fluctuations in fish populations, and factors that it does not assess. The model could still provide completely false and misleading answers, even if the evaluator were extremely accurate and sampled 100% of the management area.

However, if you dispose of the model, what do you use? Is there another tool that will work better? If nothing else works better, then the question becomes whether the model helps or hinders the decision making process. The model does develop an awareness of livestock-fisheries interactions and encourages better evaluations, but this can often be done more efficiently by other means. At this stage of development the model could be more dangerous than beneficial.

COWFISH PC PROGRAM: USER'S GUIDE

[See Appendix E - diskette]

To Start:

To start COWFISH, turn on the IBM or compatible computer and get into DOS. Type in COWFISH after the DOS prompt and hit enter.

```
    A:> COWFISH (hit enter)
(assuming the COWFISH disk is in drive A:)
        or
    B:> COWFISH (hit enter)
(assuming the COWFISH disk is in drive B:)
```

If you do not have a hard disk, put the disk in the default drive and turn the machine on. It should boot itself up and start the program automatically. Then just answer the prompts. If this doesn't work, get into DOS first and then put the COWFISH disk in the default drive and type COWFISH behind the DOS prompt.

Background

The program matches the algorithm outlined in the above user's guide and is very similar to Lloyd's (1986) COWFISH manual. You can change the coefficients to adjust the estimates for fish abundance to better fit your area, or you can use the coefficients Lloyd (1986) used for central Montana. COWFISH should be evaluated for the individual species and location, if it is used as a major management tool. Use the results cautiously and realize that many assumptions of the model may be violated.

Entering Data

There are two ways to enter data into the model. You can enter it from the keyboard or with a data-file. The program will ask you for the information it needs when you use keyboard entry. For entering data with a data-file you will need to have the file prepared in advance. The data-file should be in an ASCII file and arranged as described in the program help section. You can create an ASCII file using Kedit or any number of other software packages. Use the keyboard to enter data if you are not familiar with data files. The only advantage of data file entry (for this program) is if you are entering data from more than four or five streams.

For your convenience, there is a test data file (input data) available for trial runs of this program. The data file is called STREAM20.IN. Feel free to use it to familiarize yourself with the program. The program will ask you for a drive and file name for an output file. The program gives an example, but you can call the file whatever you want. If you give it a name of an existing file it will replace everything in the existing file. You can examine both input and output files with an editor of some kind such as KEDIT. You can also import the input and output files to Word Perfect 5.0 because they are ASCII files.

Errors

"?Redo from start" If you get a "?redo from start" error, just type in the data again (correctly) and hit enter and continue. This error occurs if you enter alpha characters where the program is

looking for numbers. Be sure to use ZERO not the letter "O" for 0, and use 1 for one and not the small "l." Be sure to enter stream width and depth in the same units.

1010 Error On line 1010 of the program code is a printer command. If the printer is off, disconnected, or the port path is not LPT1, then the program will crash and give this error.

Crash If for some reason the program hangs-up or crashes, you can hit ALT-CTRL-DEL keys all at the same time. This is similar to turning the machine off but it will get you going again.

Compatibility

No attempt was made to make this program compatible with semi-compatible basic programs and DOS systems. If it will not run on your PC try it on an IBM with DOS 2.1 or newer, before you assume the disk is bad.

Input Data Needed -- You will need the following data to run the program:

1. Stream name
2. Site name or code
3. Site length and unit abbreviations (100m)
4. Date or date code
5. Percent undercut bank
6. Percent alteration
7. Percent overhanging vegetation
8. Percent embeddedness
9. Mean stream depth (use same units as stream width)
10. Mean stream width (use same units as stream depth)
11. Percent channel gradient (1 ft. rise in 100 ft. run = 1%)
12. Drainage type (granitic or non-granitic)

Caution

The COWFISH model makes many assumptions. Many of these assumptions are not stated in the manual or in this program. Evaluations of COWFISH in Montana, Idaho, Utah, and Nevada streams has shown that COWFISH can be misleading in terms of fish abundance predictions.

To Stop

To get out of BASICA and back into DOS type SYSTEM after the "OK" prompt and hit ENTER.

To Start Again

Type COWFISH and hit ENTER to get back into the COWFISH program if you got out of BASICA and into DOS. Type COWFISH by the DOS prompt while the current drive has the COWFISH disk in it.

Files on COWFISH Disk

There are a number of files on the COWFISH disk. The function of each file is outlined below:

AUTOEXEC.BAT This file allows the program to self-boot by just turning on the machine while the COWFISH disk is in the drive.

COMMAND.COM This file is the computer command file and is needed for self-booting of the COWFISH disk.

COWFISH.II This file is the COWFISH program itself; BASICA code in an ASCII file.

COWGUIDE.WP5 This is the WordPerfect 5.0 file that contains this manuscript.

STREAM20.IN This is the example input data file for trial runs through the program.

BASICA.COM This is the command file to run the BASICA language. If you don't have BASICA this is real important. Also, it allows the program to self-boot.

COWFISH.BAT This is a batch file that gets the COWFISH program going when you type COWFISH in the default drive behind the DOS prompt (assuming the COWFISH disk is in the default drive).

COWFISH.IIB This is the back up file of COWFISH.II.

FIELD INFORMATION FORM

A. Background Information Map Unit ____________________

Allotment ________ Number __________ Forest __________ District ____________

Range Type(s) ______________ Pasture ______ No. ______ Elevation ____________

Livestock Class ____________________

Range Type ________ Range Suitability ________ Slope Class ____________

Season of Use ______________ Grazing System ____________

Location 1/4 Section ________ Township ________ Range ____________

Stream ______________________ Date ____________

Observer(s) ____________________

B. Site Information

1. Riparian Habitat Type (percent)
   - __________ grass/forbs
   - __________ sedges
   - __________ grass/willow (< or = 50% willow)
   - __________ grass/willow (>50% willow)
   - __________ willow/conifer
   - __________ other (specify)

2. Side valley slope gradient of the riparian zone (left; looking downstream)

   Left Bank ______% Right Bank ______%

3. Dominant Streamside Cover (percent)

	Left Bank (Looking Downstream)	Right Bank
a. palatable shrubs	________	________
b. unpalatable shrubs	________	________
c. tree form	________	________
d. grass forb	________	________
e. >50% soil, rock	________	________

4. Percentage forage utilization in riparian zone ________%

(cont'd)

C. Data

1. Percent streambank undercut. (PSI-1) ________%
2. Percent streambank with overhang vegetation. (PSI-2) ________%
3. Streambank alteration.
   The percentage of each bank that has exposed soil, trampled vegetation, or other forms of stress. (PSI-3) ________%
4. Substrate embeddedness. (PSI-4) ________%
5. Average stream width. (PSI-5) ________%
6. Average stream depth. (PSI-5) ________%
7. Average stream gradient. ________%
8. Granitic soils present. [ ] yes [ ] no

D. Comments

Observer's evaluation of riparian habitat trend and cause of any degrading or improving riparian habitat conditions.

Observer's comments on solutions to any degradation problem:

Remarks (diversions, crossings, trailing areas, etc.):

CALCULATION FORM

	Data	PSI
1. PSI-1 (streambank undercut)	________%=	________
2. PSI-2 (vegetative cover overhang)	________%=	________
3. PSI-3 (streambank soil alteration)	________%=	________
4. PSI-4 (stream embeddedness)	________%=	________
5. PSI-5 (stream width/depth ratio) width ____/depth_____ = ___/___	=	________
	Total =	________
6. Calculate Mean PSI (Total divided by 5)	Mean PSI =	________
7. Habitat Suitability Index (Percent of Habitat Optimum) (the percent form of (6), Mean PSI)	(HSI) =	_______%
8. Optimum Stream Width Stream Width ______ x PSI-5 = (If PSI-5 is less than 0.5 then use 0.5)		________

9. Optimum Fish Production = (8) x ZZ

Where ZZ equals:

0.75 for granitic drainages, stream gradients > 5.0;
1.50 for granitic drainages, stream gradients < 5.0;
2.00 for non-granitic drainages, stream gradients > 5.0;
5.00 for non-granitic drainages, stream gradients < 5.0.

Optimum Fish Production = ________

10. Existing Fish Production = (9) x (7) __________ per 300m

11. Fish Loss = (9) - (10) __________ per 300m

12. Recreation Loss = (11) - 6 = _______ WFUD per 300m per year

13. Economic Loss = (12) x $63.87 _______ per 300m per year

METHODS

STREAM TEMPERATURE MODEL

INTRODUCTION

Streams today, especially in the western United States, are subject to a variety of forms of degradation. Often one subtle change is stream temperature. Most problems causing stream temperature effects probably fall into four categories: 1) stream channel alteration due to grazing, channelization or mining; 2) riparian vegetation destruction due also to grazing, farming practices, timber management, or flooding; 3) removal of water through diversions or groundwater pumping; and 4) impoundment construction. Resulting stream temperature changes can have a profound influence on the quantity and quality of aquatic life supported by the stream. The astute manager will consider stream temperature as one variable in the impact or mitigation analysis.

It has long been difficult to predict how alternative management actions influence stream temperatures. There is now a set of microcomputer programs that make such calculations relatively painless. Developed by the U.S. Fish and Wildlife Service, these public domain programs can be a great help in comprehending the factors that control stream temperatures, understanding the sensitivity of those factors, and accurately estimating the effects of changing those factors through planned management actions.

The use of these programs, known as the Stream Segment Temperature Models, is described in this section. A sequence of steps is outlined in the User's Guide to introduce each of the program components, help in estimating or measuring model variables, and grasping the significance of the program output. Next, an example problem and solution are presented. Though simplistic, it adequately represents a common real-world situation. The last section is devoted to where you can learn more about applied stream temperature modeling, if you wish.

USER'S GUIDE TO THE STREAM TEMPERATURE SEGMENT MODELS

Defining the Problem

No set of computer programs can ever really tell you what you are trying to do; you have got to define that for yourself. You must decide before proceeding what the problem is and give some thought to what might be done about it. For example, do you know or suspect that grazing may have resulted in a particular stream exceeding critical thermal thresholds for a fish species of interest? Could it be that a proposed timber sale will encroach on a stream and you want to know how temperatures will be affected? Do you need to decide how much water can be diverted from a stream and still keep maximum temperatures below some threshold? Do you even have a handle on what those thresholds are and how close you may be to them? What management actions may be available to you to influence stream temperatures? Can you help control the bank slope, prevent overgrazing, control streamflow? These things must be known.

Given that these generalities have been defined, you should reduce the scope somewhat by putting temporal and spatial bounds on the problem. Narrowing things to a particular time of year and a specific geographic area will help immensely. Luckily, these decisions are usually not difficult. Making them will also help you get started on temperature modeling, because those models assume that you are looking at a stream with a defined length at a certain time of year.

You will generally proceed through three distinct steps in temperature modeling. First, you will determine the day length and amount of solar radiation at your specific locale using the **SSSOLAR** program. Second, you will determine how much of that incident solar radiation is screened out due to the topography (valley and/or streambank) and riparian vegetation using the **SSSHADE** program. Third, you will combine what you have learned with other stream geometry (length and width), meteorology (air temperature, humidity, etc.), and hydrology (flows) to determine the mean and maximum stream temperatures in the **SSTEMP** program.

The remainder of this section covers each of these three steps in much more detail, starting with information useful from them all.

In each of these programs, it is assumed that all stream data is characterized by average conditions. It is also assumed that water in the system is instantaneously and thoroughly mixed at all times. Thus there is no lateral temperature distribution across the stream channel, nor is there any vertical gradient in pools. Finally, this set of programs is only valid for northern hemisphere applications.

General Program Operation

Before we begin, it is assumed that the practitioner is at least passingly familiar with microcomputers that use the DOS operating system. One must have an IBM-compatible microcomputer with at least 128K of RAM memory and a disk drive supporting the size diskettes you received with this publication. An 80-column printer that can print the IBM graphic character set is desirable, but not required. You should locate the diskette containing the Stream Segment Temperature Models and either make a backup diskette or copy them to your hard disk. The disk file README.SST contains information on the file names for these programs and other helpful information.

Each of the programs introduced will operate much the same. Upon invoking the program, the screen will erase and you will be presented with a simple set of instructions and reminders. Some programs ask you to type a title line for your work. The opening screen will be followed by one displaying the user-controlled variables, their respective units and the "default" values. The default values are there merely to serve as a starting point and to show the approximate magnitude of the numbers. They should not be used without thought or review; undoubtedly each case modeled will require changing most variables.

If you have ever used an electronic spreadsheet program such as Lotus 1-2-3, you will have no trouble from here on. You may change any variable by using the arrow keys to move the highlight from one variable to the next. When you have positioned the cursor on top of the value you want to change, type the new value. Each value must be terminated by pressing the ENTER key or by pressing one of the arrow keys to move to a new variable. Typing a new value for any variable will immediately update the results displayed on the right side of the screen. Each variable has certain built-in upper and lower bounds to attempt to prevent outlandish user input errors. As far as this author knows, these limits are not unreasonable. However, the user should look to see that what he or she types actually shows up on the screen. The screen image will always contain the values which the model is using.

Certain program errors may occur from time to time. For example, if you accidentally enter a downstream elevation that is higher than the upstream elevation, the SSTEMP program will print an error message, and then continue. If an error should occur, you may be assured that the last value typed caused the error.

In using the arrow keys, the UP arrow and the LEFT arrow both move UP the ordered list; likewise the DOWN and RIGHT arrows move DOWN the list. On IBM compatible computers, the PrtSc key will copy the screen onto your printer. Pressing the ESC key will escape (exit) the program to the DOS operating system.

Now, let us proceed to the three unique programs you must learn.

Step 1 -- Determine the Local Solar Radiation (SSSOLAR)

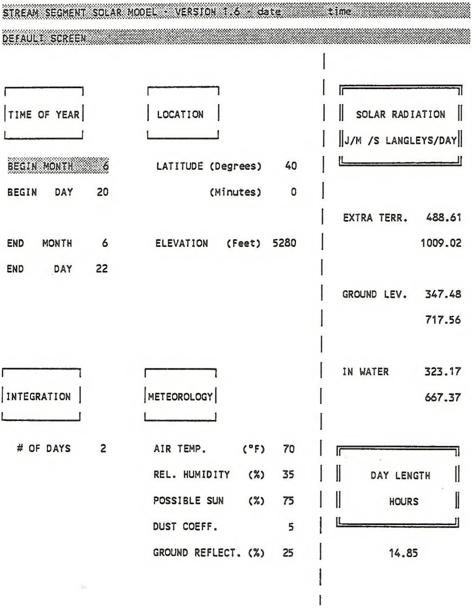
This step will involve the use of a computer program called the Stream Segment Solar Model, or SSSOLAR. This program is used to estimate the solar radiation and day length values for subsequent input into the SSTEMP temperature model. SSSOLAR calculates extra-terrestrial, ground-level and water-penetrating shortwave radiation. It begins by computing the position of the sun with respect to the location of your stream (on the earth's surface) to be modeled for the time of year in question, and calculates the radiation at the outer edge of the earth's atmosphere. This radiation is passed through the attenuating effects of the atmosphere and finally reflects off the water's surface depending on the angle of the sun. The program requires inputs describing the time of analysis, the location on the earth's surface, and meteorological conditions. The output is solar radiation that would be penetrating the unshaded water's surface, and day length.

To initiate the SSSOLAR program, type

```
"d:\path\SSSOLAR"
```

where d:\path\ is the location of the program on your computer.

After an introductory screen, you will see the default variable screen as shown below. The cursor highlights the first user-controlled variable - Begin Month:



```
STREAM SEGMENT SOLAR MODEL - VERSION 1.6 - date          time
DEFAULT SCREEN
                                                    |
 ┌────────────┐      ┌──────────┐                   |  ╓─────────────────────╖
 |TIME OF YEAR|      | LOCATION |                   |  ║  SOLAR RADIATION    ║
 └────────────┘      └──────────┘                   |  ║J/M /S LANGLEYS/DAY  ║
                                                    |  ╙─────────────────────╜
 BEGIN MONTH     6    LATITUDE (Degrees)    40      |
 BEGIN   DAY    20              (Minutes)    0      |
                                                    |   EXTRA TERR.   488.61
 END   MONTH     6    ELEVATION   (Feet)  5280      |                1009.02
 END     DAY    22                                  |
                                                    |   GROUND LEV.   347.48
                                                    |                 717.56
                                                    |
 ┌────────────┐      ┌───────────┐                  |   IN WATER      323.17
 |INTEGRATION |      |METEOROLOGY|                  |                 667.37
 └────────────┘      └───────────┘                  |
                                                    |
   # OF DAYS     2    AIR TEMP.        (°F)   70    |  ╓─────────────────────╖
                      REL. HUMIDITY    (%)    35    |  ║    DAY LENGTH       ║
                      POSSIBLE SUN     (%)    75    |  ║      HOURS          ║
                      DUST COEFF.              5    |  ╙─────────────────────╜
                      GROUND REFLECT. (%)     25    |         14.85
                                                    |
                                                    |
```

Variables

Each of the user-controlled variables will be discussed in the order in which they occur on the screen. We will discuss what each variable means and how to estimate or measure it.

Beginning Month and Day -

Enter the number of the month and day which start the time period of interest. January equals 1, February equals 2, and so forth. July usually is the hottest month for most geographic areas.

Ending Month and Day -

Enter the number of the month and day which end the time period of interest.

Number of Days -

The number of days is a factor which tells the program when and how often to sample during the period specified above. If the results are for a single day only, use 1 day. For periods between a day and a month, 2 days is sufficient. Time periods greater than a month are not recommended, but experimentation will show the sensitivity.

Latitude (degrees and minutes) -

Latitude refers to the position of the stream segment on the earth's surface. It may be read from any standard topographic map. You should enter both degrees and minutes in the spaces provided.

Elevation (feet) -

Read the mean elevation off of a topographic map.

Air Temperature (°F) -

Mean daily air temperature representative of the time period modeled. Estimates are available from the weather service or can be measured from instrumentation.

Relative Humidity (%) -

Mean daily relative humidity representative of the time period modeled. Estimates are available from the weather service or can be measured from instrumentation.

Possible Sun (percent) -

Mean daily percent possible sun representative of the time period modeled. This is, in effect, a surrogate for cloud cover. Ten percent cloud cover is 90% possible sun. Estimates are available from the weather service or can be measured from instrumentation.

Dust Coefficient -

This dimensionless value represents the amount of dust in the air. Representative values look like the following:

Winter	-	6 to 13
Spring	-	5 to 13
Summer	-	3 to 10
Fall	-	4 to 11

If all other variables are known, the dust coefficient may be calibrated by using known ground-level solar radiation data. But for our purposes here, simply choose an intermediate value; it is not a very sensitive variable. In other words, if you are modeling summer conditions, entering 6.5 will suffice.

Ground Reflectivity (percent) -

The ground reflectivity is a measure of the amount of shortwave radiation reflected back from the earth into the atmosphere. Representative values look like the following:

Meadows and fields	14
Leaf and needle forest	5 to 20
Dark, extended mixed forest	4 to 5
Heath	10
Flat ground, grass covered	15 to 33
Flat ground, rock	12 to 15
Flat ground, tilled soil	15 to 30
Sand	10 to 20
Vegetation, early summer	19
Vegetation, late summer	29
Fresh snow	80 to 90
Old snow	60 to 80
Melting snow	40 to 60

Ice	40 to 50
Water	5 to 15

Thus, a typical grazing situation would have a value of about 24.

<u>Output</u> -

The results from the program will be shown on the right side of the screen. The short wave radiation units are shown in Joules per meter squared per second and in Langleys per day, the latter the common English measurement unit. The values to be carried into SSTEMP are the radiation penetrating the water and the daylight hours.

Step 2. Determine Solar Shading (SSSHADE)

This program may be used to estimate the combined topographic and vegetative shade for a single stream segment on a daily basis. It calculates the ratio of solar radiation intercepted by local topographic features and riparian vegetation to the total daily solar radiation on a smooth earth's surface (level plain). This program computes the position of the sun with respect to the location of the stream segment on the earth's surface. The day length is then computed for the level plain case, i.e., as if there were no local topographic influence. Next the local topography is factored in by recomputing the sunrise and sunset times based on the east and west side topography. Thus, the local topography results in a percentage decrease in the level plain daylight hours.

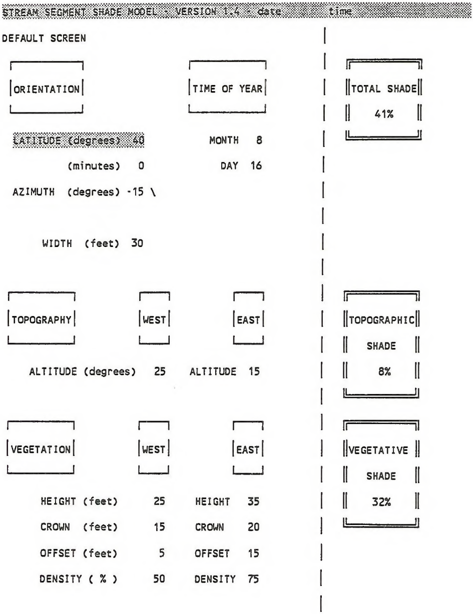
From this local sunrise/sunset, the program then computes the percentage of light which is filtered out from the vegetation. This filtering is the result of the size, position and density of the shadow-casting vegetation on both sides of the stream. The program requires inputs describing the orientation of the stream segment, time of year to be modeled, topographic angles, and vegetative variables. The result is percent shade, which is a necessary input for the Stream Segment Temperature Model (SSTEMP).

To initiate the SSSHADE program, type

```
"d:\path\SSSHADE"
```

where d:\path\ is the location of the program on your computer.

After an introductory screen, you will see the default variable screen as shown below:



```
STREAM SEGMENT SHADE MODEL - VERSION 1.4 - date        time

DEFAULT SCREEN                                        |
                                                      |
 ORIENTATION                  TIME OF YEAR            |   TOTAL SHADE
                                                      |       41%
 LATITUDE (degrees)  40          MONTH   8            |
         (minutes)    0            DAY  16            |
 AZIMUTH  (degrees) -15 \                             |
                                                      |
     WIDTH  (feet)  30                                |
                                                      |
 TOPOGRAPHY              WEST             EAST        |   TOPOGRAPHIC
                                                      |      SHADE
    ALTITUDE (degrees)    25    ALTITUDE   15         |       8%
                                                      |
 VEGETATION              WEST             EAST        |   VEGETATIVE
                                                      |      SHADE
      HEIGHT (feet)       25     HEIGHT    35         |       32%
      CROWN  (feet)       15     CROWN     20         |
      OFFSET (feet)        5     OFFSET    15         |
      DENSITY ( % )       50     DENSITY   75         |
                                                      |
```

Variables

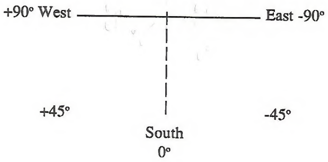
Each of the user-controlled variables will be discussed in the order in which they are found on the screen. We will discuss what each variable means and how to estimate or measure it. Some variables will be identical to those in other segment temperature programs.

Latitude (degrees and minutes) -

Latitude refers to the position of the stream segment on the earth's surface. It may be read from any standard topographic map. You should enter both degrees and minutes in the spaces provided.

Azimuth (degrees) -

Azimuth refers to the general orientation of the stream segment with respect to due South and controls the convention of which sides of the stream are called East and West. A stream running North-South would have an azimuth of 0°. A stream running Northwest-Southeast would have an azimuth of -45 degrees. The direction of flow does not matter. Refer to the following diagram for guidance:



Once the azimuth is determined, usually from a topographic map, the East and West sides are fixed by convention. When the angle is small, East and West are obvious. As the angle approaches plus or minus 90 degrees, it is less clear. Imagine an azimuth of plus 90 degrees; the actual north shore is termed West. Similarly, if the azimuth is minus 90 degrees, the north shore is termed East as far as this program is concerned. This convention is easy to understand if you visualize varying the azimuth from zero degrees and noting that West and East always stay on the same side of the stream.

Since azimuth can be confusing to many people, the program prints a "/" or "\" character to the right of the entry which designates the general orientation of that entry.

Width (feet) -

Refers to the average width of the stream from water's edge to water's edge for the appropriate time of the year. Note that the width and vegetative offset should usually be changed in tandem. That is, as the width increases, the offset decreases. Stream width may be measured in the field or estimated from low-level aerial photographs.

Month -

Enter the number of the month to be modeled. That is, January equals 1, February equals 2, and so forth.

Day -

Enter the number of the day of the month to be modeled. This program's output is for a single day. To compute an average shade value for a longer period (up to one month) merely use the middle day of that period. The error encountered in so doing will usually be less than one percent.

Topographic Altitude (degrees) -

This is a measure of the average incline to the horizon from the middle of the stream. Enter a value for both East and West sides. The altitude may be estimated from topographic maps or measured with a clinometer. In hilly country, the topographic maps will usually be appropriate; in mountainous terrain, it will be difficult to estimate topographic altitudes from a topo map; in flatter country, the streambank itself may be the overriding horizon. Be careful!

Vegetation Height (feet) -

This is the average height for the shade-producing strata of vegetation from the water's surface. Enter a value for both East and West sides.

The height may be calculated by the formula H = D * TAN(A), where H is the height, D the distance from the observer (in the water) to the vegetation, and TAN(A) the tangent of the angle from the water surface to the tops of the vegetation. This angle may be measured with a clinometer, just like the topographic altitude.

Vegetation Crown (feet) -

This is the average maximum crown diameter for the shade-producing strata of vegetation along the stream. Enter a value for both East and West sides. Estimation from aerial photos may be used, but direct measurements will likely be more reliable.

Vegetation Offset (feet) -

This is the average offset of the trunks of the shade-producing strata of vegetation from the water's edge. You may need to vary this if you vary the stream width. Enter a value for both East and West sides.

Vegetation Density (percent) -

This is the average screening factor (0 to 100%) of the shade-producing strata of vegetation along the stream. It is composed of two parts: the continuity of the vegetative coverage along the stream (quantity), and the percent of light filtered by the vegetation's leaves and trunks (quality).

For example, if there is vegetation along 25% of the stream and the average density of that coverage is 85%, the total vegetative density is .25 times .85, which equals .2125, or 21.25%. The value should always be between 0 and 100%. Enter a value for both East and West sides.

To give examples of shade quality, an open pine stand provides about 65% light filtering; a closed pine stand provides about 75% light removal; relatively dense willow or deciduous stands remove about 85% of the light; a tight spruce/fir stand provides about 95% light removal. Areas of extensive, dense emergent vegetation should be considered 90% efficient for the surface area covered. If you wish to be more precise, follow the procedure outlined below.

Purchase from a photographic supply store an item called an 18% gray card (about $5). Using an accurate, hand-held light meter, set the ASA value to a low number, such as 25. Set the f-stop to a high value, such as 16. Stand in direct sunlight and hold the light meter about six inches from the gray card such that the light meter only picks up light reflected from the gray card, being careful to cast no shadow yourself on the gray card. Read the exposure time from the meter; we will call the denominator of that exposure time E_o. Now repeat the measurement in the shade. This denominator we will call E_i. Then use the following formula to calculate the filtering effect:

$$\text{Shade quality} = 1.0 - (E_i / E_o)$$

For example, if the in-shade exposure time is 1/50th of a second and the out-of-shade exposure time is 1/350th of a second, then:

$$\text{Shade quality} = 1.0 - (50 / 350)$$
or
$$\text{Shade quality} = 0.86$$

Shade continuity is best estimated from aerial photographs or by sampling along the streambank. Density may need to be adjusted for the time of year if you are dealing with deciduous vegetation.

Output

The program will predict the total segment shading for the set of variables you provide. The program will also display how much of the total shade is a result of topography and how much is a result of vegetation. The topographic shade and vegetative shade are merely added to get the total shade. However, one should think of topographic shade as always being dominant in the sense that topography always intercepts radiation first, then the vegetation intercepts what is left. It is the total segment shade that is carried forward into the SSTEMP program.

Step 3. Determine Resulting Stream Temperatures (SSTEMP)

The program requires inputs describing the average stream geometry, as well as (steady-state) hydrology, and meteorology and predicts the minimum, mean and maximum daily water temperatures at some specified distance downstream. The program also handles the special case of a dam with steady-state release at the upstream end of the segment.

The temperature calculation is essentially done in two steps. First, the heat balance is calculated to determine the rate of heat entering or leaving the stream. Next, the heat is transported downstream. The resulting downstream temperatures (minimum, mean, and maximum) are displayed on the right side of the screen as are the mean, and maximum daily equilibrium temperatures. Intermediate values calculated by the program also are displayed (mean stream width and depth, as well as the heat balance components).

To initiate the SSTEMP program, type

"d:\path\SSTEMP"

where d:\path\ is the location of the program on your computer.

This program includes several keys in addition to those of the other programs. For example, the HOME and END keys may be used to move around the variable list. In addition, typing a "U" will toggle the Units system from English to Metric and vice versa. Other options are available, but beyond the scope of this discussion.

After an introductory screen, you will see the default variable screen as shown on the following page.

Variables

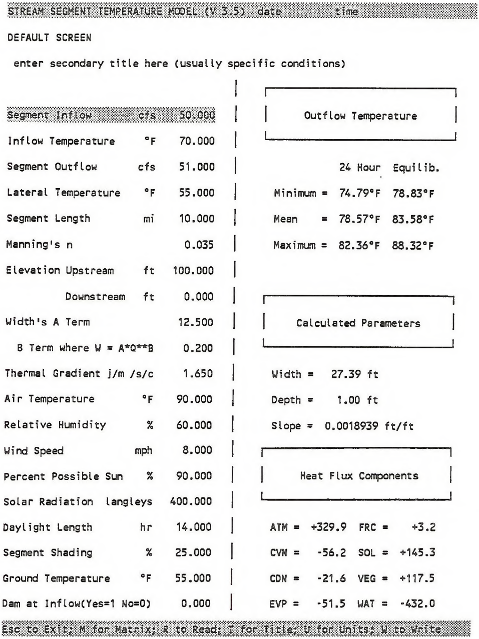
Each of the user-controlled variables will be discussed in the order in which they are found on the screen. We will discuss what each variable means and how to estimate or measure it. Some variables will be identical to those in other segment temperature programs.

Segment Inflow (cfs or cms) -

Enter the mean daily flow at the top of the stream segment. If the segment begins at a true headwater, the flow may be entered as zero; all accumulated flow will accrue from lateral (groundwater) inflow. If the segment begins at a reservoir, the flow will be the outflow from that reservoir. Remember, this model assumes steady-state flow conditions.

Inflow Temperature (°F or °C) -

Enter the mean daily water temperature at the top of the segment. If the segment begins at a true headwater, you may enter any water temperature, because zero flow has zero heat. If there is a reservoir at the inflow, use the reservoir release temperature. Otherwise, use the outflow from the upstream segment.



```
STREAM SEGMENT TEMPERATURE MODEL (V 3.5)  date          time

DEFAULT SCREEN

 enter secondary title here (usually specific conditions)

                                         |    ┌──────────────────────────────┐
Segment Inflow           cfs    50.000   |    |     Outflow Temperature      |
Inflow Temperature        °F    70.000   |    └──────────────────────────────┘
Segment Outflow          cfs    51.000   |              24 Hour  Equilib.
Lateral Temperature       °F    55.000   |      Minimum =  74.79°F  78.83°F
Segment Length            mi    10.000   |      Mean    =  78.57°F  83.58°F
Manning's n                      0.035   |      Maximum =  82.36°F  88.32°F
Elevation Upstream        ft   100.000   |
          Downstream      ft     0.000   |    ┌──────────────────────────────┐
Width's A Term                  12.500   |    |    Calculated Parameters     |
  B Term where W = A*Q**B        0.200   |    └──────────────────────────────┘
Thermal Gradient j/m /s/c        1.650   |      Width =   27.39 ft
Air Temperature           °F    90.000   |      Depth =    1.00 ft
Relative Humidity          %    60.000   |      Slope =  0.0018939 ft/ft
Wind Speed               mph     8.000   |    ┌──────────────────────────────┐
Percent Possible Sun       %    90.000   |    |     Heat Flux Components     |
Solar Radiation  langleys      400.000   |    └──────────────────────────────┘
Daylight Length           hr    14.000   |      ATM =  +329.9  FRC =    +3.2
Segment Shading            %    25.000   |      CVN =   -56.2  SOL =  +145.3
Ground Temperature        °F    55.000   |      CDN =   -21.6  VEG =  +117.5
Dam at Inflow(Yes=1 No=0)        0.000   |      EVP =   -51.5  WAT =  -432.0
Esc to Exit; M for Matrix; R to Read; T for Title; U for Units; W to Write
```

Segment Outflow (cfs or cms) -

The program calculates the lateral discharge by knowing the flow at the head and tail of the segment, subtracting to obtain the net difference, and dividing by segment length. The program assumes that lateral inflow (or outflow) is uniformly apportioned through the length of the segment. If any "major" tributaries enter the segment, you probably should divide the segment into two or more subsections. "Major" is defined as any stream contributing greater than 10% of the mainstem flow.

Lateral Temperature (°F or °C) -

The temperature of the lateral inflow, barring tributaries, should be the same as groundwater temperature. In turn, groundwater temperature is often very close to mean annual air temperature. You can verify this by checking United States Geological Survey (USGS) well log temperatures. Exceptions may arise in areas of geothermal activity. If irrigation return flow makes up most of the lateral flow, it may be warmer than mean annual air temperature. Return flow temperature may be approximated by equilibrium temperatures.

Segment Length (miles or kilometers) -

Enter the length of the segment for which you want to predict the outflow temperature. Remember that all variables will be assumed to remain relatively homogeneous for the entire segment. Length may be estimated from a topographic map.

Manning's n (dimensionless) or Travel Time -

Manning's n is an empirical measure of the stream's "roughness." A hydrologist can help you estimate or measure the stream roughness. A generally acceptable default value is 0.035. This variable is necessary only if you are interested in predicting the minimum and maximum daily fluctuation in temperatures. It is not used in the prediction of the mean daily water temperature, and it is not a particularly sensitive variable.

Values for this variable greater than 1.0 will be interpreted by the program as Travel Time (seconds per mile or kilometer). Dye studies may yield very accurate measures of travel time.

NOTE: This model does not allow either Manning's n or travel time to vary as a function of flow as they really should.

Upstream Elevation (feet or meters) -

Enter elevation as taken from a 7-1/2 minute quadrangle map. Do not enter an upstream elevation that is lower than the downstream elevation, or an error message will appear.

Downstream Elevation (feet or meters) -

Enter elevation as taken from a 7-1/2 minute quadrangle map. Do not enter a downstream elevation that is higher than the upstream elevation, or an error message will appear.

Width's A Term (dimensionless) -

This variable may be derived by calculating the wetted width vs. discharge relationship. Again, an experienced hydrologist can help. To conceptualize this, plot the width of the segment on the Y-axis and discharge on the X-axis of log-log paper. Be sure to use consistent units. Three or more measurements are much better than two. The relationship should approximate a straight line, the slope of which is the B term (the next variable). Theoretically, the A term is the Y intercept when X equals 1. However, the width vs. discharge relationship tends to break down at very low flows. Thus, it is best to calculate B as the slope and then solve for A in the equation:

W = A * Q^B

where Q = known discharge
W = known width
^ = exponentiation

Regression analysis also may be used to develop this relationship. First transform the flow to natural log (flow) and width to natural log (width). Log (width) will be the dependent variable. The resulting X coefficient will be the B term and the (non-zero) constant will be the A term when exponentiated. That is:

A = e ^ constant from regression

As you can see from the width equation (W = A * Q^B), width equals A if B is zero. Thus, substitution of the stream's actual wetted width for the A term will result if the B term is equal to zero. This is satisfactory if you will not be varying the flow, and thus the stream width, very much in your simulations. If, however, you will be changing the flow by a factor of 10 or so, you should go to the trouble of calculating the A and B terms more precisely. Width can be a sensitive factor under many circumstances.

Width's B Term (dimensionless) -

From the above discussion, you can see how to calculate the B term from the log-log plot. This plot may be in either English or International Units. The B term is calculated by linear measurements from this plot. A good estimate in the absence of anything better is 0.20; you may then calculate A if you know the width at a particular flow.

Thermal Gradient (Joules/Meter^2/Second/°C) -

This elusive quantity is a measure of rate of thermal input (or outgo) from the streambed to the water. It is not a particularly sensitive variable. In the absence of anything better, simply use the 1.65 default. Note that this variable is measured in the same units regardless of the system of measurement selected.

Air Temperature (° or °C) -

Enter the mean daily air temperature. This information may of course be measured, and should be for truly accurate results; however, this and the other (following) meteorological variables may come from weather reports which can be obtained from a weather station near your site.

NOTE: Air temperature will usually be the single most important factor in determining water temperature.

Relative Humidity (percent) -

Obtain the mean daily relative humidity for your area by measurement or from the weather service. Often you may need to average four daily values given in a report.

Wind Speed (miles/hour or meters/second) -

Obtainable from the weather service. Wind speed also may be useful in calibrating the program to known downstream temperatures by varying it within some reasonable range.

Percent Possible Sun (percent) -

This variable is an indirect measure of cloud cover. Ten percent cloud cover is 90% possible sun. Estimates are available from the weather service or can be measured from instrumentation.

Solar Radiation (Langleys/day or Joules/meter^2/second) -

Enter the results from the SSSOLAR program. If you use a source other than SSSOLAR, you should assume that about 90% of the ground-level solar radiation actually enters the water. Thus, multiply any recorded ground-level solar measurements by 0.90 to get the radiation actually entering the water.

Daylight Time (hours) -

Adjust this time between sunrise and sunset for the time of year. You may use the SSSOLAR program to calculate this.

Segment Shading (percent) -

This variable refers to how much of the segment is shaded by vegetation, cliffs, etc. If 10% of the water surface is shaded, enter 10. To be truly accurate, the Stream Segment Shade Model (SSSHADE) should be used to predict the actual shading value based on topography, vegetative coverage, and vegetative density. In lieu of using the shade program, you may think of the shade factor as being the percent of water surface shaded at noon on a sunny day. In actuality, shade represents the percent of the incoming solar radiation that does not reach the water.

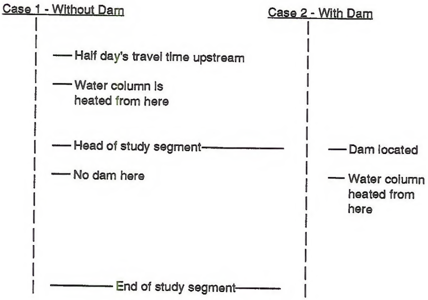
Ground Temperature (°F or °C) -

Use mean annual air temperature from the weather service. (See "Lateral Temperature" above.)

Upstream Dam (Y/N) (Yes = 1 No - 0) -

If a reservoir is supplying the segment inflow, enter a 1, otherwise enter a 0.

The maximum daily water temperature is calculated by following a water column from solar noon to the end of the segment, allowing it to heat up towards the maximum equilibrium temperature. If there is an upstream reservoir or spring that is a source of constant temperature water, and its distance upstream is less than the travel time of water from solar noon to the end of the segment, the water column from the dam's discharge is heated instead of the water column a full half day's travel upstream (see below.) The stream segment's meteorology and geometry supplied as variables will apply to the distance upstream through which the water column travels.


Case 1 - Without Dam
Case 2 - With Dam
Half day's travel time upstream
Water column is heated from here
Head of study segment
No dam here
Dam located
Water column heated from here
End of study segment

Calculating maximum daily temperature with and without an intervening dam.

Output

The program will predict the 24-hour minimum, mean, and maximum daily water temperature for the set of variables you provide. The theoretical basis for the model is strongest for the mean daily temperature. The maximum is an estimate and may vary depending on several different factors. The mean daily equilibrium temperature is that temperature which the daily mean water temperature will approach, but never reach, if all conditions remain the same (forever) as you go downstream. (Of course, all conditions cannot remain the same, e.g., the elevation changes immediately.) The maximum daily equilibrium temperature is that temperature which the daily maximum water temperature will approach.

Other results include the intermediate variables average width, average depth and slope, calculated from the twenty input variables, and the heat balance components. These heat balance components are abbreviated as follows:

ATM = atmospheric component
CVN = convection component
CDN = conduction component
EVP = evaporation component
FRC = friction component
SOL = solar radiation component
VEG = vegetative radiation component
WAT = water's back radiation component

The sign of these components shows whether or not heat is entering (+) or exiting (-) the water. The units are in joules/meter^2/second.

Bringing it all Together: An Example

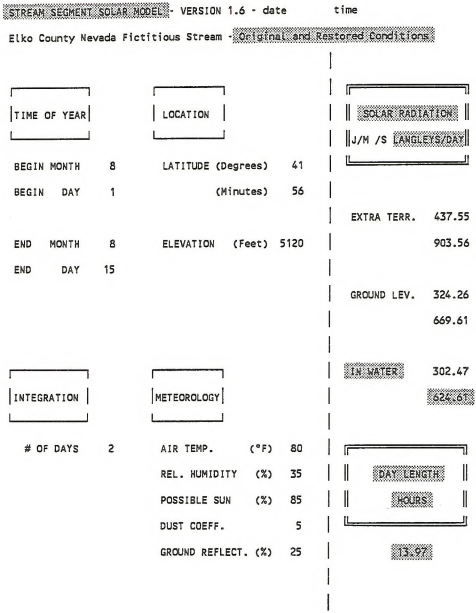
You have been asked to evaluate the potential thermal benefit of restoring an 8.1-mile section of overgrazed stream in northeastern Nevada that is thought to have high water temperature problems. You have little time and no money to devote to a detailed assessment. But a brief site visit is always in order, taking with you a topo map, measuring tape, clinometer, and calibrated thermometer. After this, and two phone calls, one to USGS, and one to the local weather service, you are ready to begin.

Your site visit reveals a high gradient stream flowing out of some hills into a broad, open grassland. The stream has been severely degraded, supporting virtually no riparian vegetation. At the foot of the hills, you take a water temperature measurement between 10:00 a.m. and 2:00 p.m. to get an estimate of the mean daily temperature. At several locations, you measure the stream width and take clinometer measurements of the topography. Taking a few photographs can help your memory when you get back to the office.

Your phone calls have told you a lot. The weather service had a local observer near your site where they kept air temperature records from 1949 to 1986. They look up the statistics for you. August is the hottest month, with a mean monthly maximum air temperature of 94 °F, standard deviation of 3 °F. The mean monthly minimum temperature was 54 °F, standard deviation also 3 °F. The average of these, plus two standard deviations to account for the 95% extreme condition, is 80 °F. The mean annual temperature is 50 °F, a good starting point for the ground temperature.

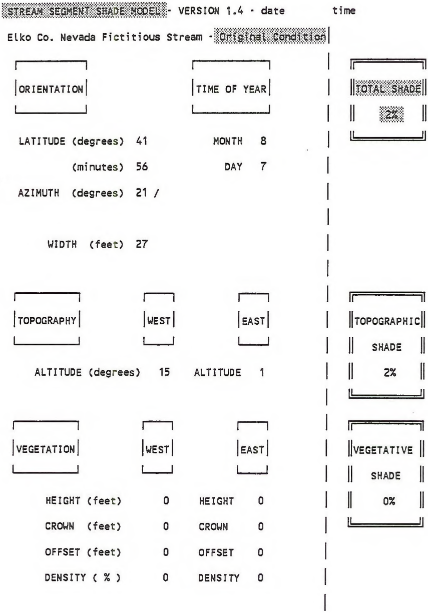
Luckily, USGS has had some gages in the area since 1918. If the stream were ungaged, that means more work for you. But if there are nearby records, you can get an idea of when flows are low and their approximate magnitude. In this case, USGS can estimate the minimum August flow to be about 8.2 cfs. This is not the lowest daily flow on record for August, but the minimum monthly flow, probably more representative of overall low flow conditions.

If you are not a fisheries biologist, you must make one more phone call. That call, or a look in a book, will reveal that trout in the area will not live in a stream where maximum daily temperatures exceed 77 °F. Using what you have learned, you are ready to compute the solar radiation using the SSSOLAR program. You decide to concentrate on the first two weeks in August. Special items are highlighted in the table on the following page.



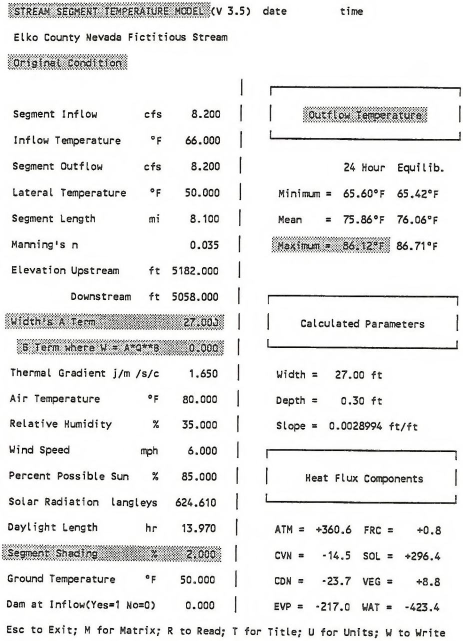
```
STREAM SEGMENT SOLAR MODEL - VERSION 1.6 - date       time

Elko County Nevada Fictitious Stream - Original and Restored Conditions
                                                    |
 ┌────────────┐          ┌───────────┐              | ╔═══════════════════╗
 |TIME OF YEAR|          | LOCATION  |              | ║  SOLAR RADIATION  ║
 └────────────┘          └───────────┘              | ║J/M /S LANGLEYS/DAY║
                                                    | ╚═══════════════════╝
 BEGIN MONTH    8        LATITUDE (Degrees)    41   |
 BEGIN   DAY    1                 (Minutes)    56   |
                                                    |  EXTRA TERR.   437.55
 END   MONTH    8        ELEVATION   (Feet)  5120   |                903.56
 END     DAY   15                                   |
                                                    |  GROUND LEV.   324.26
                                                    |                669.61
                                                    |
 ┌────────────┐          ┌───────────┐              |  IN WATER      302.47
 |INTEGRATION |          |METEOROLOGY|              |                624.61
 └────────────┘          └───────────┘              |
   # OF DAYS    2        AIR TEMP.       (°F)  80   | ╔═══════════════════╗
                         REL. HUMIDITY   (%)   35   | ║    DAY LENGTH     ║
                         POSSIBLE SUN    (%)   85   | ║      HOURS        ║
                         DUST COEFF.            5   | ╚═══════════════════╝
                         GROUND REFLECT. (%)   25   |        13.97
                                                    |
                                                    |
```

The SSSOLAR output tells you that there are about 625 Langleys per day entering the unshaded water, and that daylight lasts about 14 hours. Next, you use the SSSHADE program to estimate the stream shading. Azimuth is read from your topo map. The program output looks like this:



```
STREAM SEGMENT SHADE MODEL - VERSION 1.4 - date        time

 Elko Co. Nevada Fictitious Stream - Original Condition│
                                                       │
  ┌───────────┐            ┌────────────┐              │  ╓────────────╖
  │ORIENTATION│            │TIME OF YEAR│              │  ║TOTAL SHADE ║
  └───────────┘            └────────────┘              │  ║     2%     ║
                                                       │  ╙────────────╜
   LATITUDE (degrees)  41          MONTH   8           │
            (minutes)  56            DAY   7           │
   AZIMUTH  (degrees)  21 /                            │
                                                       │
        WIDTH  (feet)  27                              │
                                                       │
  ┌──────────┐         ┌────┐        ┌────┐            │  ╓─────────────╖
  │TOPOGRAPHY│         │WEST│        │EAST│            │  ║TOPOGRAPHIC  ║
  └──────────┘         └────┘        └────┘            │  ║   SHADE     ║
     ALTITUDE (degrees)    15    ALTITUDE   1          │  ║    2%       ║
                                                       │  ╙─────────────╜
  ┌──────────┐         ┌────┐        ┌────┐            │  ╓─────────────╖
  │VEGETATION│         │WEST│        │EAST│            │  ║VEGETATIVE   ║
  └──────────┘         └────┘        └────┘            │  ║   SHADE     ║
        HEIGHT (feet)       0    HEIGHT     0          │  ║    0%       ║
        CROWN   (feet)      0    CROWN      0          │  ╙─────────────╜
        OFFSET (feet)       0    OFFSET     0          │
        DENSITY ( % )       0    DENSITY    0          │
                                                       │
```

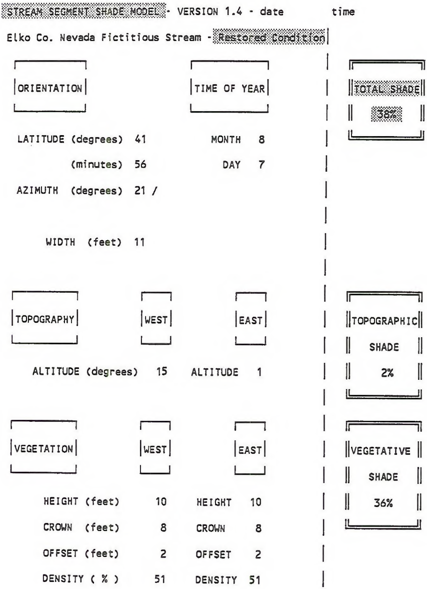
Thus, the total shade only amounts to 2%. The first look at the SSTEMP model then provides results as follows:



```
STREAM SEGMENT TEMPERATURE MODEL (V 3.5)  date        time

Elko County Nevada Fictitious Stream

Original Condition

                                      |

Segment Inflow         cfs     8.200  |     |   Outflow Temperature    |

Inflow Temperature      °F    66.000  |

Segment Outflow        cfs     8.200  |              24 Hour  Equilib.

Lateral Temperature     °F    50.000  |   Minimum =  65.60°F  65.42°F

Segment Length          mi     8.100  |   Mean    =  75.86°F  76.06°F

Manning's n                    0.035  |   Maximum =  86.12°F  86.71°F

Elevation Upstream      ft  5182.000  |

          Downstream    ft  5058.000  |

Width's A Term                27.000  |   |   Calculated Parameters   |

 B Term where W = A*Q**B       0.000  |

Thermal Gradient j/m /s/c      1.650  |   Width =   27.00 ft

Air Temperature         °F    80.000  |   Depth =    0.30 ft

Relative Humidity        %    35.000  |   Slope =  0.0028994 ft/ft

Wind Speed             mph     6.000  |

Percent Possible Sun     %    85.000  |   |    Heat Flux Components    |

Solar Radiation  langleys    624.610  |

Daylight Length         hr    13.970  |   ATM =  +360.6  FRC =    +0.8

Segment Shading          %     2.000  |   CVN =   -14.5  SOL =  +296.4

Ground Temperature      °F    50.000  |   CDN =   -23.7  VEG =    +8.8

Dam at Inflow(Yes=1 No=0)      0.000  |   EVP =  -217.0  WAT =  -423.4

Esc to Exit; M for Matrix; R to Read; T for Title; U for Units; W to Write
```

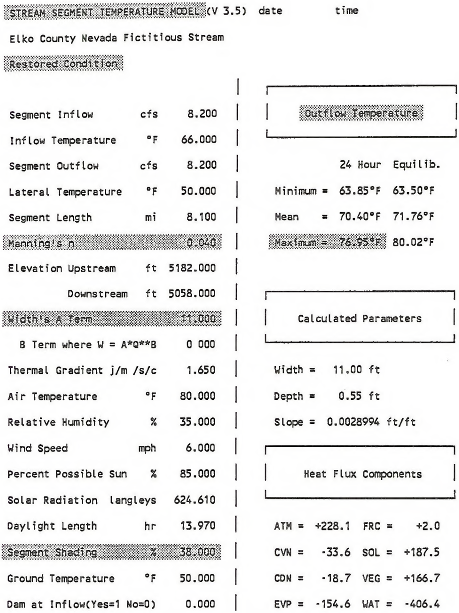
This confirms that under these conditions, daily maximum water temperatures exceed 86°F, totally unacceptable in the downstream reaches of this stream.

Next you must estimate the potential improvements resulting from a revised grazing plan. Calls to your hydrologist result in estimates of a new stream width. Your own experience tells you that you can expect about 60% of the streambank to be vegetated with willows which screen about 85% of the sunlight (51% total density) for a "virgin" stream in this area. You also estimate their height, etc., and that the increased streambank vegetation and meanders will somewhat retard the flow of water. The resulting shade for the restored condition is:



```
STREAM SEGMENT SHADE MODEL - VERSION 1.4 - date        time

 Elko Co. Nevada Fictitious Stream - Restored Condition|
                                                        |
  |ORIENTATION|          |TIME OF YEAR|               |   ||TOTAL SHADE||
                                                        |   ||   38%    ||

   LATITUDE (degrees)  41        MONTH   8             |
            (minutes)  56          DAY   7             |
   AZIMUTH  (degrees)  21 /                            |
                                                        |
       WIDTH  (feet)  11                               |
                                                        |
  |TOPOGRAPHY|       |WEST|        |EAST|              |   ||TOPOGRAPHIC||
                                                        |   ||   SHADE   ||
     ALTITUDE (degrees)   15   ALTITUDE   1            |   ||    2%     ||
                                                        |
  |VEGETATION|       |WEST|        |EAST|              |   ||VEGETATIVE ||
                                                        |   ||   SHADE   ||
       HEIGHT (feet)      10   HEIGHT   10             |   ||    36%    ||
       CROWN  (feet)       8   CROWN     8             |
       OFFSET (feet)       2   OFFSET    2             |
       DENSITY ( % )      51   DENSITY  51             |
```

Thus, the shade has been increased from 2% to 38%. What about temperature for the restored condition? It looks like this:



```
STREAM SEGMENT TEMPERATURE MODEL (V 3.5)  date        time

Elko County Nevada Fictitious Stream

Restored Condition
                                          |   ┌──────────────────────────────┐
Segment Inflow         cfs      8.200     |   |     Outflow Temperature      |
Inflow Temperature      °F     66.000     |   └──────────────────────────────┘
Segment Outflow        cfs      8.200     |             24 Hour  Equilib.
Lateral Temperature     °F     50.000     |    Minimum =  63.85°F  63.50°F
Segment Length          mi      8.100     |    Mean    =  70.40°F  71.76°F
Manning's n                     0.040     |    Maximum =  76.95°F  80.02°F
Elevation Upstream      ft   5182.000     |
          Downstream    ft   5058.000     |   ┌──────────────────────────────┐
Width's A Term                 11.000     |   |    Calculated Parameters     |
  B Term where W = A*Q**B       0 000     |   └──────────────────────────────┘
Thermal Gradient j/m /s/c       1.650     |    Width =    11.00 ft
Air Temperature         °F     80.000     |    Depth =     0.55 ft
Relative Humidity        %     35.000     |    Slope =  0.0028994 ft/ft
Wind Speed             mph      6.000     |   ┌──────────────────────────────┐
Percent Possible Sun     %     85.000     |   |     Heat Flux Components     |
Solar Radiation  langleys     624.610     |   └──────────────────────────────┘
Daylight Length         hr     13.970     |    ATM =  +228.1   FRC =    +2.0
Segment Shading          %     38.000     |    CVN =   -33.6   SOL =  +187.5
Ground Temperature      °F     50.000     |    CDN =   -18.7   VEG =  +166.7
Dam at Inflow(Yes=1 No=0)       0.000     |    EVP =  -154.6   WAT =  -406.4
```

The result of decreasing the width and increasing the shade and Manning's n has been to lower the maximum daily temperature to just below the 77°F threshold. In fact, it is so close that given an uncertainty of about 2°F for this kind of scoping analysis, you must expect that not all of the stream will be thermally protected all of the time. Removing uncertainty, if necessary, will cost you through more detailed data collection. But you can be assured that the temperature conditions will be greatly improved.

RESOURCES FOR FURTHER LEARNING

Should you get interested in learning more about these methods and programs, you may wish to pursue the following literature from which most of the above material was derived:

Bartholow, J.M. 1987. Stream Segment Temperature Models, Aquatic Systems Branch, U.S. Fish and Wildlife Service. Fort Collins, Colorado. Program and documentation for microcomputers. (On disk.)

Bartholow, J.M. 1989. Applied Stream Temperature Analysis: Field and Analytic Methods. Instream Flow Inf. Pap. 13. Aquatic Systems Branch. Biol. Rep. 89(17). 139 pp.

Theurer, F.D., Voos, K.A., and Miller, W.J. 1984. Instream Water Temperature Model. Instream Flow Inf. Pap. 16. U.S. Fish and Wildlife Service FWS/OBS-84/15. Approx. 200 pp.

Appendix F, this document. Figures included on the diskette in Appendix F may help in a scoping-level analysis. They were taken from:

U.S. Dept. of Commerce, 1983. Climatic Atlas of the United States. National Climatic Data Center. Asheville, NC. 80 pp.

METHODS

FISH-SEDIMENT RESPONSE MODEL

INTRODUCTION

This program, FS1B.EXE, contains the original sediment yield and fish habitat response relationships that appeared in the unpublished manual:

Guide for Predicting Salmonid Response to Sediment Yields in Idaho Batholith Watersheds, by R. Stowell, A. Espinosa, T.C. Bjornn, W.S. Platts, D.C. Burns, and J.S. Irving, 1983, USDA Forest Service, Northern and Intermountain Regions, Missoula, MT, and Ogden, UT, 95 pp.

The relationships presented in the manual are used to predict expected salmonid habitat and population responses to land management practices that are expected to result in above normal sediment delivered to downstream reaches (those determined by fisheries specialists beforehand to be "critical reaches"). Expected sediment yields over natural can be predicted by the R1-R4 sediment yield model or its local variants. Guidelines for application of the R1-R4 model appeared in the unpublished manual:

Guide for Predicting Sediment Yields from Forested Watersheds, by R. Cline, G. Cole, W. Megahan, R. Patten, and J. Potyondy, 1981, USDA Forest Service, Northern and Intermountain Regions, Missoula, MT, and Ogden, UT, 112 pp.

Limitations

FISHSED was developed principally for the Nez Perce National Forest from data collected from local watersheds and from laboratory studies at the University of Idaho. The relationships that form the core of the model represent the state of our understanding of the relationships between sediment yield and fine sediment (depth fines and embeddedness), between embeddedness and salmonid carrying capacity, and between fine sediments (<6.3 mm) and salmonid embryo survival; it is intended primarily to model the responses of steelhead trout and chinook salmon. Use of FISHSED relationships, and therefore of this program, for fisheries in other areas or for other species may produce erroneous predictions.

This program has been tested and appears to produce accurate predictions (subject, of course, to the validity of the relationships developed by the FISHSED committee and of the predictions of the R1-R4 model). However, neither guarantee of accuracy nor applicability to a given purpose is expressed or implied. This model is merely a tool designed to facilitate the decision making process, and can in no way replace professional expertise or substitute for incomplete understanding of the systems of interest to the users.

Compatibility

FS1B.EXE was written and compiled using Microsoft QuickBASIC Version 3.00 and is accompanied by the run-time module BRUN30.EXE, a Microsoft product licensed for distribution with compiled programs. Microsoft QuickBASIC 3.00 requires either PC or MS-DOS 3.0 or later. A numeric coprocessor is not required and will not be addressed by the program if present. FS1B requires approximately 192 Kb free conventional (non-expanded) memory.

Installation

You can run FS1B from the original diskette, or you may copy it onto another diskette and run it from that diskette. It is recommended that you make at least one copy of the FS1B and the run-time module BRUN30.EXE as a backup. You may copy either or both of these programs into a pathed directory on a hard disk if you have one. If you have other programs compiled with Microsoft QuickBASIC 3.0, you need have only one copy of BRUN30.EXE available to these programs. Please note, however, that programs compiled with other QuickBASIC releases have run-time modules specific to those releases, and programs compiled with the numeric coprocessor version of QuickBASIC 3.0 will still require BRUN3087.EXE.

To copy FS1B and BRUN30.EXE, place the diskette containing the programs in drive A: and make it the current directory by typing the following at your DOS prompt (usually ">"):

```
> A: <ENTER>
```

Place a blank, formatted diskette in drive B: if using a two floppy drive system and type:

```
> COPY A:*.* B: <ENTER>
```

If you are installing to a hard disk (usually drive C:) directory, use the following syntax:

```
> COPY A:*.* C:\[directory name] <ENTER>
```

Running the Program

You can run FS1B directly from your floppy disk or from the current or any pathed directory (BRUN30.EXE must also be in the current or a pathed directory). To start, type the following at the DOS prompt:

```
> FS1B <ENTER>
```

If BRUN30.EXE cannot be found by DOS, you will receive the error message, "Cannot find BRUN30.EXE. Enter new path:" At this prompt, enter the required path. If you receive the DOS error message, "bad command or filename," you will need to make the directory (or drive) containing FS1B the current directory (or drive).

Data Entry Routine

The program will prompt you for all required input, which includes the following data:

Enter Number of Events -->

At this prompt, you must enter the number of expected events (one per year) that will raise sediment yield to above-natural levels. This number must be an integer in the range 1 to 10. Other values will generate a non-fatal error.

Yield, Event # X -->

At this prompt, you will need to enter the amount the sediment yield associated with the event is above natural. This number is a percentage, and may exceed 100%. The source of this data should be the R1-R4 model.

Enter Starting Embed. -->

This value should come from knowledge of the existing conditions of the critical reach. It can be measured, in percent, using the "hoop" or ocular techniques.

Enter Starting Fines -->

This value also comes from in-depth knowledge of the existing conditions in the critical reach. It should be the percentage of fines smaller than 6.3mm recovered from a .3m deep core sample. If such depth fine data are not available, percent surface fines may substituted; however, FISHSED was designed for use of depth fines data.

Enter Channel Type -->

This prompt requires a response of "A," "B," or "C." Channel types follow the basic scheme followed by Rosgen and various workers. A channels are typically narrow with deeply incised channels; B channels are wider, less deeply incised and more sinuous; C channels are broadest with less incised, u-shaped channels. C channels often support the best spawning habitat for anadromous salmonids.

Enter Salmonid Type -->

This prompt requires a response of "C" for chinook salmon or "S" for steelhead trout.

Enter Car. Cap. Format -->

Enter the type of format desired for reporting salmonid carrying capacity changes. The required inputs are "P" for reporting as a percent of optimum or "N" for reporting as number of fish per square meter.

Edit Routine

After all data has been entered, all or most of it will still be displayed on the screen. The program will then prompt you to indicate with a "Y" or "N" response whether the data have been entered correctly. "Y" is the default; if you answer "N" the program will redisplay the data clearly in case it had not all been displayed at the end of the input routine, and you will be prompted to indicate which data values were incorrect. Any or all data values can be changed at this time, and if more mistakes are made, they can be corrected also.

Results Section

FISHSED model predictions based on input data are presented by type (substrates, carrying capacities, and embryo survival). After all results are displayed for each type, the display will pause, waiting for a key to be pressed before the next series of results is displayed.

Wrap-up Section

After the results have been displayed, you will be offered several options:

Select Option -->

```
<P>rint Results
<F>ile Results
<R>estart Program
<S>hell to DOS
<E>xit to DOS
```

Print Results -

This choice prints the results to LPT1. No provision has been made for any hard copy alternative. However, use of the the DOS "MODE" command will allow some re-routing of printed output. For example, if your printed output is channeled through COM1, you may route it to LPT1 with the following command:

```
MODE LPT1:=COM1:
```

Consult your DOS manual for additional information about re-routing I/O.

File Results -

This option allows you to store your output on disk. After making this selection, you will be prompted for a file name. This name should be 20 characters or less in length, and should include the appropriate path specification. Standard DOS file naming rules prevail.

Restart Program -

This option allows you to rerun FS1B from the start. No values are carried over from previous runs.

Shell to DOS -

This option allows you to go to DOS command level to perform such things as DIR, TYPE, COPY, etc. Type EXIT <RETURN> to get back to FS1B.

Exit to DOS -

This terminates FS1B.

DISCUSSION

The Fisheries-Sediment Response Model (FISHSED) was originally developed to work for the planning and management of timber sales, road construction, and in some cases fire. With modification the model could be used for evaluating the effects of livestock grazing on sediment recruitment to the stream. Future plans are to do this, so this model is included at this time for familiarity and use if the user wants to modify the model to fit his or her situation. An IBM compatible computer diskette is included with this document (Appendix G) for easy use of the model. The user only has to imput the necessary data and the computer model outputs the answers.

The model predicts the effects of different management scenarios on fish populations and their habitat. The model, as stated previously can also be modified to evaluate the effects of livestock grazing, because all that is needed to make FISHSED run is the amount of delivered sediment to a reach that would be natural, that delivered under the present management, and that predicted if the management scenario were modified or eliminated.

The original model appeared in an unpublished document entitled "Guide for Predicting Salmonid Response to Sediment Yields in Idaho Batholith Watersheds" (hereafter referred to as the "Guide") (Stowell et al. 1983). This FISHSED model (hereafter referred to as "Version One") represented the best available estimates of the responses of salmonid habitat and local salmonid populations to sediment delivery rates to a specific stream reach. These best available estimates also reflected the limits of knowledge of the committee of experts that formulated Version One. To date, however, habitat and population responses predicted by Version One remain largely untested under real-world conditions.

Estimates of sediment yield over natural base levels that are predicted by forest hydrologists and soil scientists to be routed (delivered) to a critical stream reach are generated by the R1-R4 Sediment Yield Model (Cline et al. 1981). Predictions based on the R1-R4 Model represent the "best guesses" of the team of soils and hydrological experts that developed it, and the "best guesses" of local land managers that have been charged with predicting the erosional impacts of past, present, and proposed future development activities and alternatives.

The R1-R4 estimates of sediment yield for past, present, and/or proposed activities are used by FISHSED to predict subsequent changes in fish habitat and population characteristics. Consequently FISHSED predictions essentially represent expert guesswork based on more expert guesswork; weaknesses in any link of this chain are likely to be compounded as the models are used together, possibly leading to erroneous information for use in land management planning.

While it may be reasonably argued that some tools available for modeling impacts to assist the planning process is better than no tools, it is equally certain that underestimates of potential watershed and fisheries damage may encourage damaging land uses. Conversely, overestimates of sediment delivery and impacts to fisheries may result in economic losses through unnecessary nonconsumption of resources. Consequently, it is necessary to test the current version of FISHSED and to identify and correct inaccuracies, and to identify where possible any weaknesses in the input data generated by the R1-R4 Model.

This section and the diskette take this necessary step in model development by comparing FISHSED predictions with actual field measurements of habitat conditions and trout and salmon populations. Also proposed are modifications to the predictive functions and the ways in which sediment yield estimates are applied to the FISHSED model to obtain more accurate results.

Model Assumptions

All predictive models are based on a body of underlying assumptions, the validity of which ultimately determine the accuracy of the individual predictions. Consequently, any test of the model also constitutes a test of the model's assumptions. For the FISHSED model, certain assumptions have been made, discussed as follows.

Sediment Disposition Within the Critical Reach

The first and most basic assumption of FISHSED is the assumption that predictions made by the R1-R4 Model are accurate. These predictions constitute the principal variable inputs to FISHSED's predictive functions, so the accuracy of FISHSED predictions is limited first by the accuracy of the sediment yield estimates. This assumption was not tested directly in this effort, but analysis of stream channel changes and known climatic events allow some inferences regarding its validity.

One major weakness in the R1-R4 model that has a direct bearing on FISHSED predictions is that the R1-R4 Model predicts increased erosion in response to expected increases in erosion potential of soils (including streambanks) in response to alternative land-uses, and uses this prediction to forecast the increase in sediment that will be delivered to a critical stream reach (Cline et al. 1981). Sediment transport through the stream channel and disposition within the critical stream reach have not been adequately studied. In fact, Cline et al. (1981) suggest that the question of sediment disposition is the weakest link in predictions of fishery impacts using R1-R4 Model predictions.

In most mountain watersheds under natural conditions, energy available for transporting sediment exceeds sediment supply (Cline et al. 1981). Consequently, most sediments will be transported through a critical stream reach rather than being deposited; the amount that is deposited will approximate the amount that is removed from the reach; and sediment levels in the reach will appear to remain relatively constant. Minor, short-duration increases in sediment delivery will temporarily increase sediment levels in the critical reach, but they will normally be flushed quickly from the system when sediment delivery returns to normal levels. Once the sediment level exceeds the transport energy available, however, sedimentation in the critical reach will increase more rapidly. Consequently, even declining sediment yields during watershed recovery following cessation of a land-use activity may continue to increase sedimentation levels in the critical reach until sediment delivery falls below some critical threshold delivery level. This process is clear in concept; unfortunately, the value of this threshold delivery level is obscure.

The FISHSED model contains no provision for dealing with sediment disposition once it is routed to the critical reach. Consequently, application of FISHSED to sediment yield predictions is, at this time, likely to be based on single year or successive single year (increasing annual yields) predictions of sediment yield, a procedure that would be consistent with no storage of excess sediments between entries. Should sediment yields be greater than the threshold level, however, sediments may be retained in the critical reach and FISHSED predictions will underestimate actual sediment levels and overestimate fishery potential.

Limiting Factors

It is widely held among fisheries biologists that the size of fish populations is limited by habitat conditions. While it is undoubtedly true that certain characteristics of the habitat exert more influence over populations than others, and that certain habitat variables can assume values that are lethal to fish, it is less clear whether, under natural or near-natural conditions, fish populations are limited by habitat features.

The assumption that habitat characteristics limit populations disregards the potential importance of such social regulating factors as territoriality and predation. When one assumes that a single habitat feature can predict the status of a fish population, the potential for error increases substantially. However, FISHSED uses functions that attempt to predict population characteristics from one habitat variable.

Embryo Survival and Emergence

Information about the intra-gravel requirements of developing salmonids is currently far from complete. It is widely accepted among fisheries biologists that excessive fine sediments in the egg pocket can kill developing embryos by restricting the intra-gravel flow that is needed to deliver dissolved oxygen and removed waste products. There have been several studies (e.g. McCuddin

1977; Tappel and Bjornn 1983; Irving and Bjornn 1984) reported that tend to support the existence of a negative relationship between fine sediments in spawning gravels and embryo survival and fry emergence. Some of the assumptions incorporated in Version One need closer examination, however, because their accuracy is crucial to predictive precision.

Sediment Sizes

Whether relative abundance of fine sediments in the egg pocket alone limits embryo survival and emergence has not been proved. There are several prevailing attitudes as to what sediment size classes, ranging from 0.83mm on up to 9.5mm, comprise "fine" sediments. Which size categories of fines are critical and what developmental phases they impact most are obscure. Clearly, the smaller the material the more likely it is to restrict intra-gravel flow, and the smaller fines may therefore be the most destructive to developing embryos. Fines that are too large to significantly retard intra-gravel flow, however, may still be too small to permit larvae to move upward in the redd and emerge from the gravel.

Laboratory Studies

Field studies of embryo survival and emergence are few, so Version One incorporates laboratory-derived relationships of percentage of fine sediments (<6.3mm) to alevin emergence to predict embryo survival from increases in sediment yield. The tacit assumption that such laboratory results can be used to predict real world situations is open to serious debate. The major potential flaw in this assumption is that laboratory studies use a simulated redd with "simplified, unnatural gravel mixtures" (Everest et al. 1987) that may bear little resemblance to natural redds. Even more to the point, Chapman and McLeod (1987) were referring to the laboratory studies used in FISHSED when they stated that "[i]t is always inappropriate to extrapolate such information to field conditions."

Another weakness in the assumption of applicability of laboratory studies regards the definition of fine sediments. Studies have commonly used sediments of 6.3mm and smaller, 4.8mm and smaller, and 0.85mm and smaller. As mentioned previously, FISHSED is based on studies that used sediments less than 6.3mm in diameter. Sediments of 4.8 to 6.3mm have been counted as gravel rather than fine sediments elsewhere (e.g. Platts et al. 1983). If the fine sediments limiting embryo survival were actually smaller than 4.8mm (or even 0.85mm), then using the percentage of 6.3mm and smaller sediments as a criterion should introduce a large amount of variability into the relationship between fine sediment and survival of embryos.

In this study, the relationship between chinook salmon embryo survival and emergence was tested, as used in Version One by plantings of eyed eggs in natural redds and nearby streambottom sites at various known fine sediment concentrations.

Winter and Summer Carrying Capacities

Several key assumptions are used by FISHSED to predict changes in winter and summer trout and salmon carrying capacities from changes in aquatic habitat conditions due to predicted changes in sediment delivery. Validity of these assumptions is debatable, but nevertheless crucial for accurate predictions by FISHSED.

Winter Carrying Capacity -

The relationship between aquatic habitat condition and winter carrying capacity (i.e. the density of fish that can be supported by the habitat during the winter) is presently an active research arena. FISHSED assumes that rubble bottoms of pool habitats are key areas for over-wintering salmonids, and laboratory-derived relationships from Bjornn et al. (1977) are used to predict changes in fish density in response to changes in the embeddedness of this habitat. Use of these relationships requires two fundamental assumptions: first, that embeddedness is either the principal factor limiting over-wintering capacity to support juvenile salmonids, or is an accurate surrogate for the actual limiting factor; and, secondly, that laboratory findings can be extrapolated directly to natural situations. Both of these assumptions are debatable.

As embeddedness increases, the interstitial space in the streambottom substrate decreases, thereby reducing the extent and quality of these protective refuges in which salmonid fry can escape winter conditions. There is no obvious reason to question this relationship in a qualitative sense, but there is evidence that embeddedness may not be the only factor that determines winter carrying capacity. Hillman et al. (1987) demonstrated that placing rubble piles in potential in-channel wintering areas increased the number of chinook salmon fry that began the winter there;

however, the effect of the rubble piles was greatest when located near such areas of cover as undercut streambanks. Similarly, Swales et al. (1986) associated successful over-wintering habitat for chinook salmon that remained in small interior rivers with deep pools containing large debris, and for coho salmon with ponds and pools that contained organic cover.

A strong case was made previously for using caution when extrapolating laboratory studies of embryo survival and emergence to field situations; similar cautions are required with predictions of winter carrying capacity based on embeddedness. Chapman and McLeod (1986) devote several pages to criticism of such extrapolation, and have even singled out the use of relationships from Bjornn et al. (1977) in FISHSED. The principal objection of Chapman and McLeod (1987) to using the relationships of Bjornn et al. (1977) in FISHSED is the high density of fish used in their artificial channels and the correspondingly high densities that the relationships would predict at low embeddedness. Chapman and McLeod (1987) contend that this result may be due to excessively high stocking densities in the artificial channels. Whatever the cause, fish densities predicted by FISHSED in response to virtually any embeddedness level are too high for even undisturbed streams. Inspection of these relationships suggests that densities as high as 16 fish/m^2 (age 0 cutthroat trout) are reasonable at 0% embeddedness, falling off to about 4 fish/m^2 at 100% embeddedness. A recent survey of fish densities in western streams (Platts and McHenry 1988) lists no instance of cutthroat trout densities over 2.51 fish/m^2 in either the Pacific or Columbia Forest ecoregions; most densities were much lower.

Use of the embeddedness-fish response curves of Bjornn et al. (1977) in FISHSED was modified to allow determination of percent of natural density as a hedge against the high laboratory densities. Whether these percentages are reliable is unknown and largely untestable. Natural carrying capacities of streams is not well known, so only actual densities can be tested in this study. Monitoring fish densities before and after a land-use activity may allow the percentage change predictions of FISHSED to be tested, but in the meantime we can only extrapolate from observed densities and embeddedness levels and estimate whether the predictions at natural embeddedness seem reasonable.

Summer Rearing Capacity -

Prediction of summer rearing capacity is fraught with some of the same dangers as prediction of winter capacity. The Guide suggests that rubble bottoms of glide habitats are key areas for summer rearing of juvenile salmonids, and FISHSED incorporates embeddedness as the key factor limiting summer rearing capacity. FISHSED relies on relationships between embeddedness and summer rearing capacity that were developed by laboratory studies of Bjornn et al. (1977), and uses the habitat criteria of Burns and Edwards (1985)[1].

Use of relationships from Bjornn et al. (1977) requires two fundamental assumptions: first, that embeddedness is the principal factor limiting summer capacity to support juvenile salmonids, or is an accurate surrogate variable; and, second, that laboratory studies can be extrapolated directly to natural situations. Use of criteria and techniques from Burns and Edwards (1985) also requires two fundamental assumptions: first, that habitat fitting their velocity and depth criteria (basically comprising runs or glides) are principal rearing habitat; and, secondly, that their techniques measure embeddedness well enough to predict fish biomass. All of these assumptions are open to question.

Measuring Embeddedness

While embeddedness and its potential effects on salmonid eggs, larvae, and fry can be readily grasped in a conceptual sense, measuring it and relating various levels of embeddness to responses in salmonid populations is much more difficult. There are several techniques that are used to measure embeddedness, each incurring its own unique cost in terms of limitations and human effort requirements. Torequemada and Platts (1988) compared embeddedness measurements obtained using several common techniques, and discuss these considerations at length. More fundamentally, however, there is little in the way of an "objective standard" by which the accuracy of the various measurements of embeddedness can be evaluated.

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[1] The Guide does not specifically indicate how embeddedness should be evaluated. The position of D. Burns as co-author and the use of runs (or glides) as primary summer rearing habitat, however, strongly suggest use of Burns' criteria and techniques. Burns and Edwards (1985) was selected as a reference because they refined the techniques used by Burns (1984).

The Guide does not specifically state the criteria or techniques that should be used with respect to embeddedness measurements when applying Version One, but its development most likely relied upon the techniques and criteria of Burns (1984) and Burns and Edwards (1985) using hoop embeddedness (Kelley and Dettman 1980). The method is very costly in terms of human effort, tends to be restricted to pre-selected instream habitat types rather than being reflective of overall reach conditions, and may pose statistical problems because of the small numbers of independent samples that are frequently taken. While hoop embeddedness offers the apparent security of being a "measured" value rather than one based on observer estimation, the results of Torequemada and Platts (1988) provide little incentive for using it rather than several less costly techniques. This chapter will use measures of embeddedness based on both the hoop and ocular (Platts et al. 1983) techniques, and will base conclusions principally upon the latter.

Channel Classification

The FISHSED model relies on channel classifications following Collotzi (1974), Espinosa et al. (1981), and Rosgen and Silvey (1980). These classifications stratify stream channels into 3 broad categories based on width, depth, velocity, discharge, gradient, bed roughness, bed material particle size, and sinuosity. For FISHSED, three principal channel types are recognized: *A-channels*, with high gradients, narrow, well incised "v"-shaped canyons, low sinuosity, large bed material, and steep adjacent slopes; *B-channels* with moderate gradients, broad, moderately incised "v"-shaped canyons, moderate sinuosity, mostly large-size bed particles with significant amounts of smaller sediments, moderately steep adjacent slopes; and *C-channels*, with low gradients, broad, poorly incised channels, considerable sinuosity, moderate to small bed particle sizes, and low-gradient adjacent landforms (see Appendix C of Stowell et al. [1981] or the cited references for more thorough descriptions of channel types).

The significance of channel classification to FISHSED lies in the differences in sediment transport and storage in the different channel types. Sediment transport competence decreases with channel type, with A-channels being the most competent and C-channels the least. Consequently, sediment yields over natural from surrounding watersheds will be felt most strongly in C-channels, which also happen to be the most likely channels to support anadromous fish spawning areas. The FISHSED model uses calculated relationships between embeddedness and sediment delivery over natural, and between depth fines and sediment delivery over natural, to predict in-channel fish habitat responses to increases in sediment yield.

Although the functional relationships used reflect observational data, it is not clear whether they incorporate cumulative effects of sustained above-natural sediment yield or whether they are merely point estimates. This consideration is analogous to that discussed for sediment disposition and is a potential source of error.

The accuracy with which FISHSED can predict changes in embeddedness and depth fines is obviously dependent on the validity of these functional relationships. These relationships can be directly tested by comparing FISHSED predictions with actual channel conditions.

Testing Areas

The FISHSED model was tested in two disjunct drainages in the Northern Rocky Mountain Physiographic Province (Fenneman 1931) in the State of Idaho. This separation promoted testing in two distinct portions of the Idaho Batholith, each possessing differences in physical and cultural characteristics.

Sediment Yield Data

Predictions of sediment yields were obtained from the Nez Perce and Payette National Forests. These outputs represented predictions of the respective forests' variants of the R1-R4 sediment yield model (Cline et al. 1981). These predictions reflected local erosion conditions in each forest based on past and present land-use activities only; no consequence of unusual weather conditions were included. Data were presented numerically as total yield (tons/year) and amount over base (percent) by watershed, as well as graphically for the period 1957 through 1986.

Non-Cumulative Approach

This approach assumed that a sediment-producing event on the watershed was essentially independent of succeeding events of lesser magnitude; consequently, it ignored any consequences related to watershed recovery[1].

Thus, if a sediment-producing event of some magnitude were followed by an event of greater magnitude, both events were considered to have contributed to off-site fish habitat degradation. If, however, the first event were followed by an event of lesser magnitude, only the first event would have been considered to have contributed to downstream habitat degradation. If streams can adequately flush sediments routed to them from the first event before excess sediments are delivered by the succeeding event, the assumption would be valid. This is the simplest application of the FISHSED model, and the one most likely to be routinely employed.

Cumulative Approach

This approach assumed that sequential sediment yield events were not independent until a developed or pseudo-baseline yield was developed. This approach incorporated the effect of delayed watershed recovery, though it continued to ignore any effects of aquatic habitat recovery. Thus, the two scenarios described above would each have had two events that contributed to downstream degradation. If streams could not flush themselves between successive events, even if succeeding events were smaller than preceding events, then this assumption would be valid. This approach is somewhat more complicated than the non-cumulative approach, but not excessively so. This approach intuitively seems more reasonable than the non-cumulative approach, because sediment deposited by watershed events may be stored in certain low gradient reaches despite their rapid removal from higher gradient reaches. In addition, a recognized consequence of watershed development is widening of downstream channels, which will reduce streamflow and increase sediment storage.

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[1] Watershed recovery is a process distinct from aquatic habitat recovery. After completion of a land-use activity, the watershed is left in a disturbed state. Secondary vegetational succession will push the watershed back toward its pre-development condition, but restoration will not be immediate. Consequently, the disturbed watershed will continue to deliver increased sediment yield to the critical reach until vegetational conditions have recovered sufficiently to eliminate the excess. Post-development yields will most likely never revert to pre-development levels; the chronic, post-development level will therefore represent the developed or pseudo-baseline.

Physical Habitat Relationships

Once Version One was used to generate predictions of fish habitat and population response to predicted increases in sediment delivery, the predictions were evaluated in light of actual field data. Actual field conditions were then used to derive more realistic coefficients for use in the model's predictive routines.

Model Refinement

The two approaches to model application described above are the only ways in which an inexperienced user would be likely to use Version One, and probably represent the manner in which the design committee intended it to be used. They seem, however, to be rather naive approaches to predicting responses of fish populations and habitat to watershed development, and some more sophisticated approaches are indicated. In addition, we have examined actual relationships between habitat conditions and fish populations, which need to be incorporated to improve FISHSED's accuracy.

Local Approach

This approach to model refinement will incorporate a correction for aquatic habitat recovery with the basic non-cumulative approach. Thus, predictions of fish population and habitat responses will not be immediately negated after a sediment increasing activity ceases, and some residual effects will be incorporated in FISHSED's predictions. While aqautic habitat recovery is only poorly understood and, for Idaho Batholith streams, has been studied at length only on the South Fork Salmon River (Torequemada et al. in press), some function modelling recovery would seem to be desirable. Consequently, since the Guide states that the SFSR recovery rate was about 12% annually, we have used this figure in examining potential model refinements.

Global Approach

This approach combined the cumulative approach with anticipated consequences of aquatic habitat and watershed recovery. Aquatic habitat recovery following heavy accumulation of instream sediment is poorly understood, as are the effects of declining but above normal yields during watershed recovery. In the long term, instream sediment must be in balance with sediment delivery. Catastrophic inputs of sediment, or successive land use inputs well above natural levels should increase sediment accumulation in the critical reach. Following cessation of these events, the streambed should begin recovering. Recovery processes on Idaho Batholith streams have only been carefully monitored on the South Fork of the Salmon River (SFSR) (Torequemada et al. in press). Recovery was simulated by decrementing the difference between the peak sediment yield and the developed or pseudo-baseline by 20% annually over a 5-year period to determine what we have called an "effective yield."

Physical Habitat Relationships

The physical habitat relationships that were developed for examining the results of Version One predictions were used to formulate new predictive functions in Version Two. The changes were incorporated in the coefficients of the depth fines-embryo survival and the embeddedness-fry density functions to better reflect field conditions rather than laboratory conditions.

Results

Using the non-cumulative approach, all predictions except depth fines appear unrealistic. Observed embeddedness (ocular) was much higher than predicted embeddedness. Even the hoop embeddedness estimate was higher than the corresponding predicted value.

Observed summer trout densities were far below the rearing capacities predicted by FISHSED. Platts and McHenry (1988) report trout densities from several Idaho streams, and averaging their reported values yields a density of 0.10 fish/m^2, approximately the densities observed.

Restricting ocular embeddedness measures to glide habitat had little effect on the magnitudes of the differences between observed and predicted levels. Predicted summer carrying capacities for steelhead trout fry were more than two orders of magnitude greater than observed trout densities. Steelhead and cutthroat trout fry were not distinguished in this study, but densities were so low compared to predicted capacities that this inconsistency is probably irrelevant; indeed, since cutthroat should exhibit higher densities (according to response curves in Appendix E of the Guide), over-prediction by the model may be even more severe than the data suggest at first glance. Average density for 2 rainbow trout streams reported by Platts and McHenry (1988) was 0.11 fish/m^2, 38% and 120% greater, for densities observed.

Depth Fines and Embryo Survival

Survival studies in 1986-87 represented minimum survival values. Potential loss of emerging larvae through the unclosed tops of the egg baskets and possible incursion of predators into the artificial egg pockets prevent using 1987 results in any more absolute fashion. This situation was largely rectified in the 1987-88 plantings in the Poverty Flat site, though some cases of ruptures in the tops of the baskets occurred.

The response functions used by Version One generally predicted higher survival than was actually observed even when there was no larval escapement through open basket tops. There were a few instances of actual survival being higher than predicted, particularly in the 1987-88 plantings, and two of the observed survival figures for the NFRR site were much higher than predicted; survival in these cases exceeded predictions by 39% and 51%, respectively.

In some ways, the actual point scatters were similar to the data scatter in the model's response curve. Specifically, there was potentially high but quite variable survival in the range of about 15% to 30% depth fines. Considerably more instances of very low survival occurred in our field data than are shown on FISHSED's survival curve, possibly because of inherent differences between field and laboratory conditions, or weaknesses in the design of the field tests (e.g. potential for alevin escape and predation). For the Poverty Flat data, there is no evidence that any embryo survival can be expected when depth fines exceed about 27%.

The high variability in survival makes the use of gross predictions of average survival based on the relationships of Figures IV-1 and IV-2 more realistic. Figure IV-1 shows the relationship in the Clearwater drainage. The relationship depicted in Figure IV-2 was developed for the South Fork Salmon River (SFSR) and may be shifted somewhat toward higher survival at higher depth fines levels for the Clearwater drainage. Figure IV-3 shows all relationships. Red River has high survival points to about 30% fines and a 38% survival at about 60% fines. It is possible Red River stocks could tolerate higher amounts of fines. We have only minimum survival data that apply, but suggest expanding the "good zone" to about 30% depth fines; expanding the "marginal zone" the same 10% would make the "dead zone" begin at about 37% depth fines.

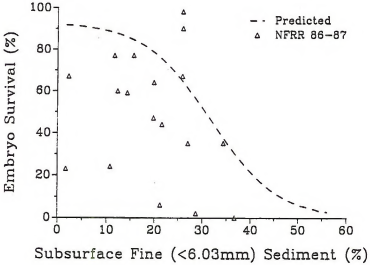

Figure IV-1. Relationship between percent depth fines and minimum chinook salmon embryo survival, North Fork Red River, 1986-1987.

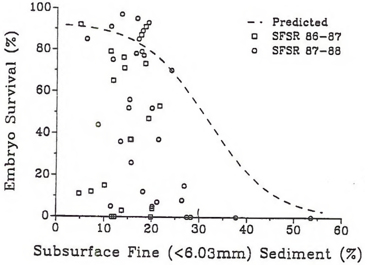

Figure IV-2. Relationship between percent depth fines and chinook salmon embryo survival, Poverty Flat, South Fork Salmon River, 1986-1988.

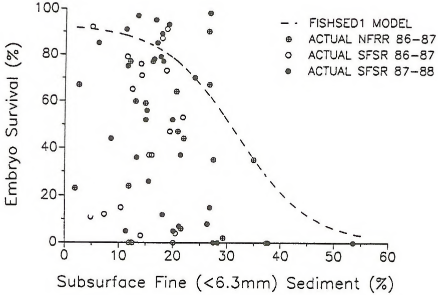

Figure IV-3. Egg to alevin survival success as a function of fine sediment (<6.3mm) concentration in artificial egg pockets, Poverty Flat (SFSR) and North Fork Red River study areas, 1986-1987.

Embeddedness and Summer Rearing Capacity

Summer rearing capacities predicted by FISHSED were clearly much higher for trout, in terms of actual numbers of fish, than observed densities, while actual chinook fry densities were higher than predicted. Plotting of our observed fry densities of trout against observed embeddedness produced a positive relationship while chinook salmon fry densities exhibited the expected negative relationships. We have not evaluated whether conversion of densities from actual values to percentages of full capacity is a more appropriate predictor, but in view of the apparently positive relationship we observed, we would not expect a substantially different outcome.

Our results for fry densities as a function of embeddedness suggest not only a complete revision of the functions used to predict rearing capacity based on embeddedness, but also a philosophical overhaul of the common belief among many fisheries biologists that increasing embeddedness is necessarily a bad thing. While chinook fry densities did fall with increasing embeddedness, their densities were higher than predicted; FISHSED Version Two thus incorporates the linear functional relationship. Trout fry densities, regardless of species, actually increased somewhat with embeddedness, and Version Two thus incorporates the curvilinear relationship.

Summary

Problems with FISHSED Version One belong to two categories: structural problems, those related to the validity of the studies used to develop the model and the coefficients selected for generating predictions; and philosophical difficulties, those related to model design. Both of these problems present users with difficulties in relating model inputs (e.g. R1-R4 model outputs) and outputs (e.g. FISHSED Version One predictions) to the real-world situations they face[1].

The clearest example of the need to incorporate ecological interactions in modeling fisheries responses to management activities is reflected in our embryo survival results. Embryo survival in the SFSR was highly variable over the range of zero to about 20% depth fines, and ranged from zero to 100% survival. We have termed this region the "good zone" because average survival was quite high, but the high variability suggested that other environmental factors were generally more important determinants of survival than depth fines. From about 20% to 27% depth fines, survival remained variable but appeared to generally be declining. We have termed this region of the curve the "marginal zone" because survival was only moderate, suggesting that depth fines were becoming increasingly important as determinants of survival. We have termed the region above 27% depth fines the "dead zone" because it appears that depth fines become an absolutely limiting factor in this range, and no survival can be expected. Consequently, functional relationships used to model survival in Version Two ignore this region, attempting to predict survival only in the region where there is some real likelihood of survival.

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[1] It must be noted that some of the difficulty with respect to the philosophical failings of Version One are created by inadequacy in the R1-R4 mode. Specifically, the R1-R4 model leaves the user of FISHSED without any clue as to how to incorporate the related factors of sediment disposition within the critical reach and overall watershed recovery processes. The fact that Version One fails to allow for watershed recovery or in-reach sediment storage is probably due to the same failure in the R1-R4 model.

METHODS

SURFACE AND GROUNDWATER MODEL

INTRODUCTION

This section presents hydrology of riparian systems in three sections. The first section reviews some basic principles, beliefs, truisms, and rules of thumb. The second section presents details on some of the topics discussed in the first section. The third section applies the topics to typical tasks encountered by the riparian/wetland manager.

This section will introduce concepts, suggestions, and present statements of beliefs, truisms, principles, and rules of thumb.

Nonpoint Sources and Watershed Management

A *nonpoint source* contrasted to a point source refers to a pollutant source from other than a pipe or very discrete point. Nonpoint sources are typically associated with disturbance of land or land that may naturally provide pollutants.

The management of nonpoint sources will likely be the water resources emphasis for the remainder of time. If this becomes true (and even if it doesn't), it is important that land users become wise land managers and understand the concept of the watershed, the uses it provides, and the impact that improper management can impart throughout a watershed.

Many of the existing and proposed Clean Water Act regulations are beginning to consider the interactive nature of the watershed system (particularly with wetland disturbance and other Section 404 procedures). The complexity of the watershed system is also being recognized by the courts as in the 1984 G-O Road decision by the Ninth District Circuit Court of Appeals. This decision pointed out the necessity of cumulative water quality impacts, the necessity to mitigate and analyze *in detail* the measure and its effectiveness, and that adherence to Best Management Practices do not automatically assure compliance with the Clean Water Act.

Watershed management and health can be viewed in terms of four basic variables:

Water Quality
Water Quantity
Erosion
Geomorphology

Water quality refers to chemical constituents and physical characteristics of water used to determine its suitability as a habitat media or consumptive or non-consumptive use. This includes the standard chemical constituents, trace metals, introduced pollutants (including bacteria and virus), temperature, sediment, and other physical characteristics.

Water quantity refers to the availability of water at any point on the watershed where a use is dependent. Typically, water quantity would include both extreme high and low behaviors of streams, lakes, groundwater systems, and soil.

Erosion refers to the soil loss/gain through upland processes and its subsequent transport/lack of transport to the channel.

Geomorphology refers to topographical surfaces and associated underlying materials. In most cases, geomorphology is used in reference to the stream channel, although other types may be of particular interest (Karst system). Geomorphology includes such characteristics as channel shape (width-depth, efficiency, entrenchment), channel pattern (relation of channel to valley, how it looks from an airplane), and profile (how it looks in longitudinal cross section).

These four variables, water quality, water quantity, erosion, and geomorphology, can be used together to gain an overall picture of health of the watershed. All of these are inherent nonpoint source characteristics that can govern the type of use that can be found on the watershed. While nonpoint source water quality definitions, from a legal perspective, may not recognize all of these characteristics, actions causing changes in one of these characteristics will likely have some impact on a supported use that water quality laws are attempting to protect. For example, changes in water quantity may have devastating effects on water quality. Likewise, changes in pool quality, gradient, etc. may affect temperature or other water quality constituents. Instream flow determination for fishery values is very dependent on geomorphology. Understanding sound water quality management concepts is essential to success.

The use of the four watershed factors is simple. If any of the factors are precluding a desired use (or is responsible for an undesired use) based on some type of established criteria, the watershed is in unacceptable condition. This allows a manager to assess the nature of the problem and points towards solutions in ways that consider system interaction. Additionally, it helps define the important processes enabling more finite monitoring objectives to be established.

Criteria are generally established based on broad protection requirements (such as water quality regulations), habitat requirements, or on specific knowledge of limiting factors to a particular use (as in an instream flow determination, maintenance flow study, erosion or moisture tolerance value for a particular soil or plant). Where such criteria are not available, several things should occur: the manager should decide which uses are to be protected; the specialist should conduct the literature reviews, field testing, sampling, etc. to develop criteria; the criteria should become part of a monitoring program. EPA's *Quality Criteria for Water, 1986* is an excellent source for water quality criteria including supporting references and appendices with methodologies for developing criteria. Instream flow criteria are available from the U.S. Fish and Wildlife Service (1984). Channel maintenance procedures are available from the U.S. Forest Service (1987). Little has been done in establishing good criteria for geomorphology other than what is available for various fish species through various U.S. Fish and Wildlife publications. Criteria for erosion are too general and mainly applicable to agriculture to be of much use for wildland situations. Safe estimates would be that soil forming rates should equal or exceed soil loss rates.

Concepts, Generalizations and Rules of Thumb

This section is intended to offer some general help to riparian and wetland managers. The statements may not necessarily be true everywhere. Some of the statements and certainly many of the embellishments are based on observations covering hundreds of streams in all of the western states. Use this section to help understand a system and to help you develop questions for knowledgeable hydrologists, soil scientists, wetland ecologists, and other experts.

The goal in using this section is to attempt to place into memory all of the statements and then to juggle and apply them when assessing a wetland/riparian system.

Management Considerations

Do unto others as you would have them do unto you.

An impact at one point of the watershed may cause impacts upstream and downstream from that point.

There are interactions between geomorphology, discharge, erosion, and water quality.

Water Quality

Water dissolves most anything.

Changes in temperature, nutrients, and/or gases may significantly alter chemical constituents of a stream.

Evaporation of groundwater from a capillary fringe may lead to elevated concentrations of salt. Without flooding or leaching these salts may change vegetation conditions (i.e. salt tolerant species).

Reduced flows are more susceptible to temperature change.

The solution to pollution can be and often is dilution.

Water Quantity

Flooding can be good.

Overbank flooding can be important in maintaining low flows.

The timing of high and low water is dependent on the climate, geology, and topography.

Streams associated with large groundwater systems may have unusual timing of low and high flows when compared to other streams more dependent on surface and near surface hydrology.

Extreme flooding will happen.

The storage capacity of a water source determines the persistence of the source.

Increasing the hydraulic gradient increases velocity of flow (and possibly discharge in the case of a groundwater system).

A travel time is the time water takes to get from one point on a watershed or stream to another.

As discharges increase in a stream system, travel time down the channel decreases. (Travel time is inversely proportional to discharge).

Streams with pool riffle sequences (particularly those caused by debris dams) will have longer travel times than similar streams without pools and riffles. This effect diminishes with increasing flow.

Channel roughness generally decreases with increasing flow.

Increasing wind increases evaporation.

Erosion

Smaller particles are eroded more easily than large particles.

Erosion can occur via water, wind, chemical and physical weathering, and gravity.

Erosion can be reduced by reducing the erosive element (e.g. wind or water velocity) through increasing roughness of the surface (e.g. vegetation, rip rap, shielding).

Erosion can be reduced by decreasing the detachability of the particles (e.g. vegetation roots, cohesive soil, desiccation).

The erosion potential is proportional to the potential energy of the erosive element.

The erosion potential is limited by the erodibility (e.g. migrating headcut) of the soil or geology.

Upland erosion rates and sediment transport may not be equivalent because of interim storage of sediment.

Some stored sediment will only be transported during higher than normal flows.

All erosion and sediment transport is not bad.

Some riparian and wetland species require erosional conditions for establishment.

Where there is erosion, there will be deposition somewhere else.

A change in velocity may result in a much larger proportional change in sediment transport.

Soil loss is generally inversely proportional to the strength of clays.

As the soil sodium absorption ratio increases, erosion resistance decreases.

Salinity and pH can have varying effects on erodibility depending on the type of clay involved.

Measuring sediment is expensive.

Geomorphology

A narrow, deep channel conveys water more efficiently than a shallow, wide channel.

Gravel bed rivers possess at least seven degrees of freedom: width, average depth, maximum depth, slope, velocity, riffle-pool spacing, and sinuosity. Variables controlling these responses are discharge, sediment load, size and characteristics of bed and bank, valley slope, and bank vegetation.

A dominant discharge is that which shapes and maintains the channel and most likely significant portions of the floodplain. Dominant discharge is probably a simplistic concept where in reality channel and floodplain creation and maintenance is very complex.

Often, an undisturbed channel will have a bankfull capacity near the 1.5-year flood discharge. This 1.5-year discharge is often referred to as the dominant discharge.

There is a channel geometry that is most efficient at transporting a particular size bedload at a dominant flow.

Gravel bed rivers can develop surface armor of coarser particles greater than 5mm which protect both the coarse and the fines.

Vegetation can provide significant protection to streambanks and associated floodplain. It may not be coincidental that dominant discharge recurrence interval and vegetation establishment time is about the same. Vegetation may be responsible in defining the potential channel geometry.

An inactive floodplain is often a result of unacceptable channel geometry.

An inactive floodplain may result in the stress of riparian vegetation.

As a channel becomes wider, riparian vegetation may decrease, bedload transport may decrease if the channel is originally near maximum transport capacity, the floodplain may become less effective, streambank erosion may increase.

If the channel is below maximum transport capacity and the channel widens, bedload transport may increase causing channel deepening, less effective floodplain, and possibly stressed riparian vegetation. A similar effect is likely when the banks are raised.

A stream manages its energy through erosion and deposition manifested in change in gradient, sinuosity, and channel shape.

Sediment transport does not occur uniformly across the channel. Channels often are bimodal due to secondary currents.

A stream changes its geomorphology constantly. It is always playing catch-up to change.

Diversity in geomorphology (e.g., pools and riffles) is usually beneficial to a riparian ecosystem.

Similar geomorphology is often seen in areas of similar substrate, hydrology, and vegetation.

The optimum amount of vegetation to prevent significant widening is unknown and obviously depends on many factors. One author has suggested that 50 percent cover of tree and shrub vegetation shows significant control on gravel-bed rivers.

> *"River channels in temperate regions widened by floods of recurrence intervals from 50 to more than 200 years may regain their original width in matters of months or years. In semi-arid regions, recovery of channel form depends not only upon flows but upon climatic determinants of the growth of bottomland vegetation resulting in variable rates of recovery, on the order of decades, depending upon coincident of average flows and strengthened vegetation."* (Wolman and Gerson 1978)

Suface and Groundwater Interaction

Some streams gain groundwater along their banks and bottom.

Some streams lose water through their bottom and banks.

Some streams depend solely on the water that flows into them from upstream.

Many streams do all of the above things at different times during the year.

Riparian and wetland systems may depend solely on groundwater or surface water.

Capillary action is an important process providing water to riparian and wetland species.

The effectiveness of capillary action is dependent on the soil and the interface it has with the subsurface water.

The finer the soil generally the higher the potential for capillary rise.

A fine-grained soil overlying a coarse-grained substrate will generally not have effective capillarity if the subsurface water level is below the fine/coarse soil interface.

Capillary action will usually not continue from a fine-grained soil to a coarser-grained soil.

All groundwater does not necessarily have to be anaerobic.

Often, groundwater flows adjacent to a stream in the same direction, only at velocities some 500 to 5,000 times slower.

A floodplain can provide significant storage of flood water, releasing it for later flow augmentation. Coarse-grained substrate releases water rapidly; fine-grained substrate releases water more slowly.

The floodplain storage and release of water is complex and controlled by the recharge rate (depth of flow on floodplain) into the floodplain, the thickness of the substrate above the normal channel water elevation, the texture of the channel and floodplain substrate.

Fine soil can inhibit the channel loss.

Understanding the Concepts

Some hydrologic and geomorphic concepts are presented along with specific groundwater behaviors that may be helpful in understanding the hydrology of wetland/riparian systems. This section is included as a summary of what are considered important processes and behaviors. Some of the information is well-known basic knowledge, some is based on extensive research, and some is based solely on observation.

Water Regime and Influence of Riparian Systems

The flow regime controls the forces governing the appearance and water supply of most riparian systems. The stream's flow regime affects the water supply in other parts of the riparian system. In particular, the flow regime interacts with the floodplain substrate and vegetation. Flow regime is usually described in terms of magnitude, duration and frequency of streamflow. Both the infrequent, extreme events and the more frequent less extreme events shape the riparian system, but in very different ways. Wolman and Miller (1960) pointed out that although extreme events may play an important role in shaping some floodplain, it is the less extreme and more frequent flooding events in the range of a 1- to 3-year return frequency (generally considered as bankfull in an undisturbed condition), that probably are most influential.

The supply of water is controlled by precipitation and regulated through interactions among geology, soils, and vegetation. Precipitation on impermeable soil and bedrock will enter the channel system rapidly. Conversely, precipitation on permeable, well-vegetated soil will enter a groundwater system and may not reach a stream channel for many seasons. Recognizing the dominant characteristics of the watershed and riparian system can help identify the processes controlling the rates at which water is captured and released by the system. This can lead to understanding the extent of effects that management may impart.

Floodplain and Channel Interaction

One way the floodplain and stream channel interact is through temporary water storage in the streambanks that can affect normal and high flows. Water storage is significant enough to reduce flood peaks, in some cases (Freeze and Cherry 1979). Cooper and Rorabaugh (1963) developed a number of solutions to inflow and outflow between banks. Freeze (1972), Kraeger-Rovey (1975) and Vasiliev (1987) have developed interrelated mathematical models that incorporate bank storage and streamflow interaction. Although extreme highs may have a totally different effect than more frequent flood events, any event that results in over-bank flooding affects the floodplain. Low stage flows also affect the floodplain through direct use of bank storage in maintaining low flows. Gregory et al. (1985) observed a significant retardation of flood travel times because of hydraulic channel modification from debris dams. These debris dams act to increase stream stage, storage and therefore detention time. When integrated along numerous sites, flood waters were measurably impeded. The effect of the debris dams became less effective as the flood discharges increased. This is expected considering that the effect of a submerged hydraulic control is minimized with depth as generally is the rate of total storage, particularly in an unconfined system).

Another way that the channel and adjacent floodplain interact is through the rate and magnitude of stored water available for soil-water and vegetation. The shape, size, roughness, and gradient of the channel determine the depth of water in the channel. Assuming a constant volume of water, the water column (stage) will be higher when confined in a narrow channel than when spread out over a wide channel (Figure IV-4). Compared to a wide channel, streamflow confined in narrow channels has a higher stage, resulting in a higher hydraulic potential, increasing rates of exchange between the channel, banks, beneath and sometimes above the floodplain (Figure IV-4). This becomes important when assessing the effects of incisement on soil-water regime. Channels that widen or deepen have enlarged capacities, reducing the number of overbank events and further limiting the interaction with the floodplain and reducing soil moisture through reduction in stream stage. Riparian vegetation may be affected lowering bank stability thereby increasing the widening.

Floodplain Development

The basic mechanism for building the floodplain, according to Wolman and Leopold (1956), appears to be the lateral migration or progression of the point bars rather than the fine sediment deposited during the overbank flow. Subsequent flooding then overtops and perhaps backfills the natural levees resulting in somewhat of a level surface. Over a long period of time, these bars continue to migrate within the confines of the valley walls. They found that the lateral channel migration was the result of frequent, 1- to 2-year events, and not so much the major, infrequent events. Important findings in Wolman and Leopold (1956) are: channels generally overtop their banks every year or every other year; floodplain materials may not be very homogeneous because of lateral accretion; and bank erosion is to be expected annually. This may help explain the variations and complexes in vegetation seen in some riparian systems.

Vegetation and Channel Shape

Vegetation establishing on new sediment deposits acts as both an internal binder, holding the soil together, and as a boundary layer control increasing resistance to flowing water. These actions, coupled with point bar progression, help reduce water flow and stabilize newly deposited material. The degree to which vegetation controls channel shape depends on its ability to improve the inherent substrate stability. The frequency of channel-forming discharge events and the establishment time of the roots of some plant species, are both about 1 to 3 years, and may therefore compliment each other (we have seen dozens of sites where cottonwood and willow establish and grow up to a foot in one year). Numerous researchers have documented changes in chan-

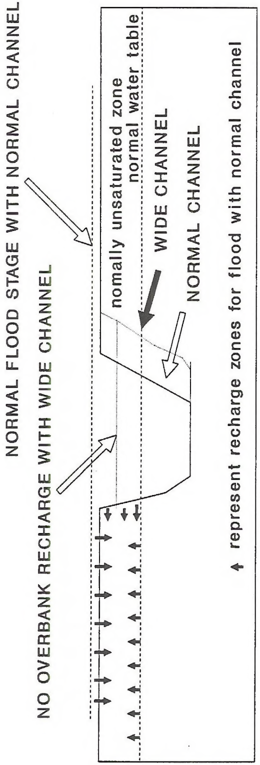

NORMAL FLOOD STAGE WITH NORMAL CHANNEL
NO OVERBANK RECHARGE WITH WIDE CHANNEL
nomally unsaturated zone
normal water table
WIDE CHANNEL
NORMAL CHANNEL
represent recharge zones for flood with normal channel

Figure IV-4. Floodplain and channel interaction as regulated by channel shape. Increased potential for floodplain recharge in normal channel.

nel geometry after vegetation loss. As early as 1959 Wolman speculated on the effect woody species might have played in reducing lateral erosion. A recent study (Hey and Thorne 1986) showed that stream width, in particular, appeared to be very dependent on vegetation. Rivers with grass banks were wider than rivers with more abundant shrub and tree species. There are also numerous documentations of changes in vegetation after channel or streamflow adjustments (Gregory and Park 1974, Andrews 1986, Park 1977). A common occurrence in western streams with cohesive bed and bank materials where vegetation is stressed or removed resulting in lower bank stability, results in streambank widening. A result is a channel with increased bankfull carrying capacity and the bankfull discharge changes from 1 to 2 years to 5 or more years recurrence interval.

Channel widening may also lead to increased bedload transport. Carson and Griffiths (1987) presented work from several authors that developed concepts of maximum channel transport. This assumes that bedload transport varies with width and there is a width that produces an optimum bedload transport. Widths above and below the optimum width produce less bedload transport. This concept could explain the vast gullying seen in the West in the late 1800's and early 1900's. A possible mechanism is explained below:

In the early 1800's western stream systems were likely in near pristine conditions, with thick fine-textured sediments overlying coarser bed material (often because of beaver domination). These conditions would generally see vegetation stabilizing streambanks with a fairly narrow channel. The bedload transport at this point would be below maximum transport capacity. Under the stresses of increased grazing pressure, overuse by beaver, other bank and vegetation disturbing activities and an increase in dominant discharge (because of deteriorated watershed condition), streambank widening occurred. This widening could increase bedload transport causing increased down-cutting. Incisement would then lead to lateral erosion as the stream slope decreased and widening also reduced the bedload transport.

Colluvial and Other Direct Deposits into Floodplain

Hillslope erosion and mass wasting provide material for the stream to use in creating a floodplain and also may detain flood waters by creating a hydraulic control or a dam. The rate and frequency of events can be accelerated by management. The substrate derived from such direct deposits varies. Obviously, direct deposits may be very significant in their influence on the substrate for riparian vegetation.

Large Woody Debris

Large woody debris may have roles in modifying flood flows, particularly where gradients and substrate limit the effectiveness or establishment of wetland vegetation. The presence of large woody debris in low order drainages may help reduce the size of peak flows in recipient drainages. In some riparian systems where substrate may not be bedrock controlled, the long-term supply of large woody debris into the system is necessary to prevent substantial degradation and maintain hydraulic diversity (i.e. pools, riffles). Gurnell and Gregory (1985) confirmed many of the above statements and also showed that the debris dams remained stable in number but not necessarily did all the debris dams stay in place year to year. Thirty-six percent of the debris dams moved or were modified while the total numbers of dams remained fairly constant.

Beavers

In many riparian systems that we have visited in the West, beaver (*Castor canadensis*) populations have been largely responsible for the establishment of the floodplain. It is common knowledge that beaver dams act functionally as detention basins, and as such, can trap a tremendous amount of material. As with many natural systems, a dynamic equilibrium between beavers, their food supply, dam material supply, and predators must exist for long-term stability of the riparian system; problems arise when the dynamic equilibrium is altered. Howard and Larson (1985) developed some prediction techniques for estimating active colony density that consider vegetation type and amount, watershed size, stream width, stream gradient and substrate permeability. In our observations on a dozen beaver dominated systems, the frequent flood event appears to do little to the functioning beaver system, and larger less frequent flood events may not cause more than some localized degradation. This lack of system degradation is probably is attributable to the continuous presence of the beaver providing a consistent, rapid, and adaptable stream control. Loss of beaver without adequate vegetation re-establishment prior to a flood occurrence can result in a very primitive, degraded channel. Bergstrom (1985) presents a good overview of beaver ecology.

Maintenance of the Channel and Floodplain

Channel maintenance flows can be thought of as flows with sufficient velocities to remove or move sediment through the system to maintain bankfull carrying capacity (of the 1- to 3-year flood) while not causing unacceptable degradation to the channel. A basis for determining and incorporating channel maintenance flows can be found in Rosgen et al. (1986).

Floodplain maintenance requires that the floodplain function in the storage and release of flood water. Maintenance of good stage levels and bankfull flows are critical for a functional floodplain and are closely inter-related to the type and amount of vegetation cover. Many of the important functions of the floodplain are covered above. Floodplain maintenance flows will likely be one of the most important and controversial determinations to be made on the watershed. We are not aware of any procedures for this determination.

Groundwater Terminology and Behavior

The following groundwater terms and behaviors are presented to help in understanding surface and groundwater interaction and in developing awareness.

Source Supply and Persistence

Supply and storage capacity are the major regulators in groundwater. Supply, or recharge, can be directly from precipitation or from other surface and groundwater sources. Groundwater systems can be described as regional, intermediate, or local. In a very large regional system, the only recharge source is precipitation although a network of local and intermediate systems may redistribute the water. Flow remains steady because of the large storage capacity and areas of contribution. Intermediate systems are basin or drainage dependent but may be large enough to persist for more than one season without recharge. They contain local systems and may have some exchange with other intermediate systems. Local systems are small and dependent on seasonal precipitation, usually requiring recharge after one season. An area with abundant small and intermediate systems is likely to be topographically diverse. Areas with few small and intermediate systems are likely to be flat. Persistence of the sources is described in terms of their size and capability to provide water throughout a growing season or beyond.

Source Type

Sources of water for riparian systems are defined as discrete or lateral. An example of a lateral source is bank seepage along a stream where the water table is above the stage of the stream. A discrete source is from defined and localized areas such as springs, geysers, seeps.

Source Dependence

Sources of water are also considered system dependent or system independent. System dependent means that the water source is from the upstream riparian system. System independent means the source is largely independent from the immediate riparian network.

Rate and Direction of Flow

Groundwater flow is predominately regulated by the permeability of the substrate, travel distance, and the difference in hydrostatic pressure (head, gradient). Fine texture material will transmit water quite slowly (clayey substrate < .1 cm/hr) when compared to coarse textured material (sand > 20 cm/hr) at a given head. The direction of groundwater flow is regulated by the alignment of the pores and cracks, the change of the substrate permeability, and hydrostatic pressure.

Channel Permeability

Channel permeability controls the rate of loss and gain of flow within the channel. A channel can be highly permeable or very impermeable depending on the texture of the substrate. A highly permeable substrate in a fines-limited system may prevent significant soil water accumulation in the banks or water table development adjacent to a stream. Some silty channels are very impermeable to loss of flow, but are more permeable to receiving flow (Kraeger-Rovey 1975). We have observed some channels that look as though they should have very permeable substrate, but on closer examination appear to exhibit a chemical cementing of interstitial pores that reduces permeability. The importance of the channel in regulating water supplies should not be overlooked.

Active-Inactive Floodplain

If the 1- to 3-year flood reaches bankfull capacity, the floodplain is considered "active." Floodplains become active or inactive through channel change or through changes in annual flood frequency (i.e. upland watershed condition). Floodplains become inactive as channel dimensions increase and the 1- to 3-year flood cannot reach overtop the bank. While these conditions may be transitional, they can have a significant effect on the soil-water regime and vegetation.

Hydraulic control refers to any number of structures or channel form which control the streamflow or groundwater velocity. Pool and riffle sequences in streams are caused by hydraulic controls in the channel. We have observed these pool and riffle sequences providing alternating seepage flows into and out of the stream (Figure IV-5). The importance of these sequences is not entirely clear; however, it appears that on some streams, storage adjacent to pools may increase riparian vegetation and extend the period of flow.

Effective Capillarity

The height of capillary rise is primarily determined by soil texture (fine texture=higher rise). Where capillarity is important for maintaining soil moisture in the upper soil layers and it is occurring, it is termed effective capillarity. If it is not occurring, it is termed ineffective capillarity. The effectiveness of capillary rise (Figure IV-6) is determined by the position of the saturated zone and by soil layering (e.g. capillary action can draw soil water up from coarse soil pore spaces into finer pore spaces but not from fine into coarse). Where coarse substrate (having little or no capillary rise potential) underlies the finer substrate, water levels must at least reach the interface of the fine and coarse material for capillary rise to occur, and often must reach above the interface for capillarity to remain effective through the growing season. Capillary action cannot be overlooked in its nutrient or salt transporting role. A significant process that may be important to the establishment of salt tolerance species of vegetation might be explained as followed:

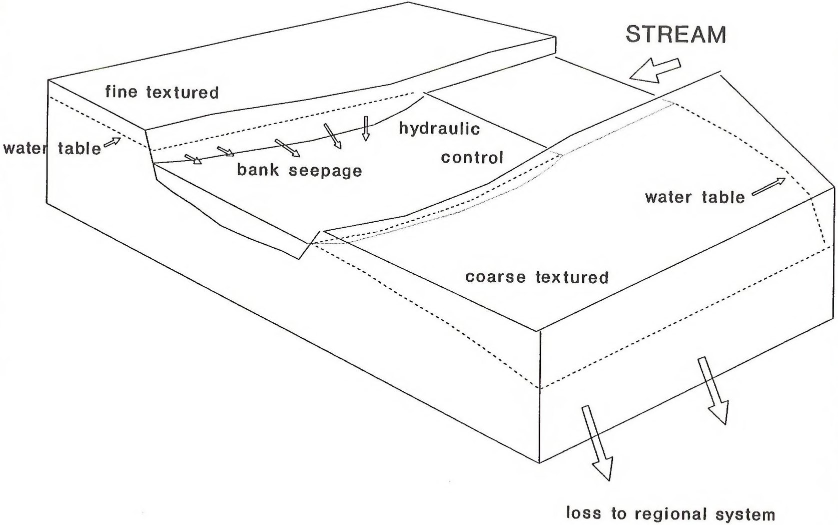

STREAM
fine textured
hydraulic
control
water table
bank seepage
water table
coarse textured
loss to regional system

Figure IV-5. Local effect of pool and riffle on bank/floodplain water storage and release.

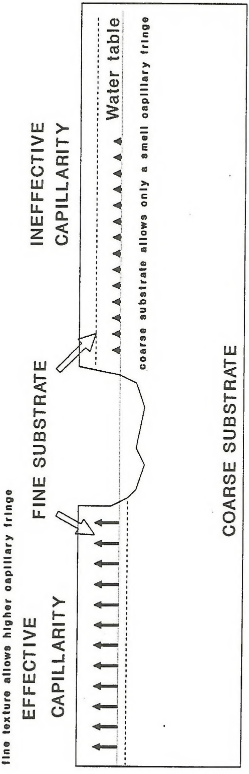

fine texture allows higher capillary fringe
EFFECTIVE CAPILLARITY
FINE SUBSTRATE
INEFFECTIVE CAPILLARITY
Water table
coarse substrate allows only a smell capillary fringe
COARSE SUBSTRATE

Figure IV-6. Effective and ineffective capillarity due to location of coarse/fine substrate interface and water table.

In southwest sand-silt bed streams, water quality is relatively high in dissolved salts. Adjacent laterally supplied groundwater may be even higher. Capillary action may act as a constant supply of water to the surface. Water is evaporated leaving elevated salt levels. Before reservoir construction, frequent flooding allowed the floodplain to become leached of the accumulating salts. Where frequent flooding is no longer allowed, salt accumulation may have been severe enough to eliminate certain species of vegetation.

APPLYING HYDROLOGY

Using Hydrology in Wetland/Riparian Classification

Classification has been used as a taxonomical procedure for years in the fields of plant ecology, soil science, zoology, and more recently in wetland/riparian management. Many classification procedures have been developed for use with wetland/riparian vegetation [Cowardin and others 1979; Brown and Lowe 1974; Youngblood and others 1985; Kovalchik 1987; Platts et al. 1987, 1988 (unpublished); Hansen et al. 1988 (unpublished); Swanson and others 1988; Hann and Jensen 1988 (unpublished)] and at least one for physical attributes (Rosgen 1985). The most recent documents we have examined attempt to classify vegetation and describe physical attributes together in a narrative-type format [Kovalchik 1987; Platts and others 1987, 1988 (unpublished)]; Hansen and others 1988 (unpublished). Kovalchik's (1987) publication includes a section entitled "Association Descriptions" where narrative descriptions are presented that appear very useful to management. Such narratives include discussions on general location, landforms, soils, floristic characteristics, vegetation ecology, management, and rehabilitation. Within discussions on management and rehabilitation are inferences to site potential, disturbance effects, and rehabilitation pathways.

The newer classification documents we have examined include a great deal of information for management application, rather than just taxonomy. Their appearance is not unlike a typical Soil Conservation Service soils survey. However, a deficient area within the riparian classification documents examined, is a lack of specific description on the hydrologic and geomorphic processes largely responsible for a site's environment. This paper presents an overall approach in viewing riparian systems and suggests some standard types of hydrologic description to be included in the narrative products of classification documents.

States of the System

In a riparian system, environmental conditions are not stable. The likelihood of soil and water environmental conditions at many riparian sites remaining stable, over several decades or even years, is remote. For example, fine sediment may be deposited over gravel (aggravation) creating a new soil or substrate with different profiles, permeabilities and other soil moisture characteristics. Other sites may be eroded or in some manner have their soil structure or water supplies altered. Therefore, a riparian site may change with time (Figure IV-7) from one defined riparian type to another through aggravation or degradation of the site or through major change of the water supply to the site. Figure IV-8 demonstrates the possible range of riparian types for a site within a larger riparian system. The boxes shown in Figure IV-8 as RT1 through RT8 represent "states" of the site and are akin to a vegetation classifier's community type. We have chosen to use the term state, rather than other units commonly used in riparian/ stream classification, to reduce confusion in terminology. State is a flexible unit and can represent many types of classification units as required by the user.

These states represent the likely appearance of a riparian site based on various environmental conditions. In describing states in this paper, we have chosen to express environmental conditions in terms of erosion resistance and soil water. Soil water is described, in general, by the persistence of the source of soil water and/or the ability of the soil to hold and release moisture to vegetation. Erosion resistance is described by vegetation condition (as it relates to soil and substrate stability), and substrate texture. Obviously, many factors could describe soil water and erosion resistance, but we have chosen those thought to be most useful in considering hydrologic process and in developing an understanding of a site's behavior.

Process Pathways

The arrows in Figure 5 represent the process responsible for a state change. The process pathways are a description of hydrologic process mechanisms responsible for the change. The cause

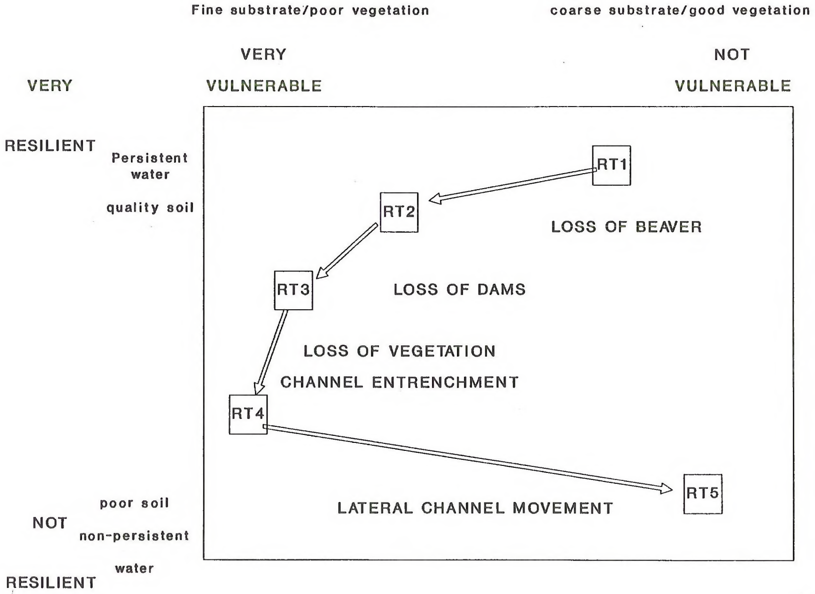
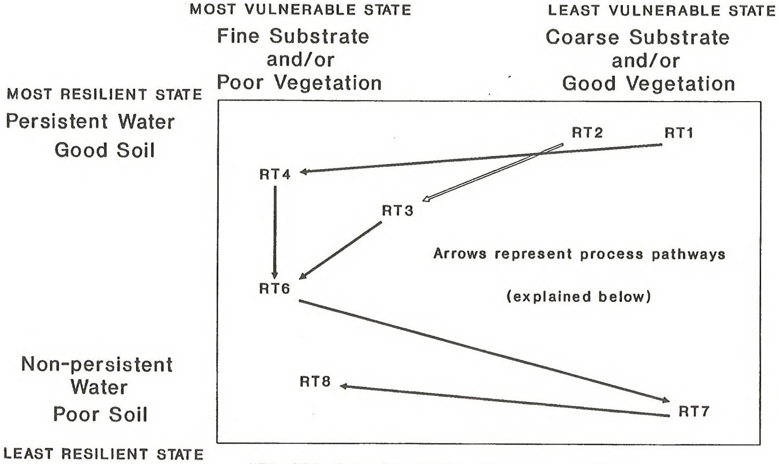

Fine substrate/poor vegetation
coarse substrate/good vegetation
VERY VULNERABLE
NOT VULNERABLE
VERY RESILIENT
Persistent water
quality soil
RT1
RT2
LOSS OF BEAVER
RT3
LOSS OF DAMS
LOSS OF VEGETATION
CHANNEL ENTRENCHMENT
RT4
RT5
LATERAL CHANNEL MOVEMENT
poor soil
non-persistent water
NOT RESILIENT

Figure IV-7. Concept of state, state change, and process pathways.


MOST VULNERABLE STATE
Fine Substrate and/or Poor Vegetation
LEAST VULNERABLE STATE
Coarse Substrate and/or Good Vegetation
MOST RESILIENT STATE
Persistent Water Good Soil
Non-persistent Water Poor Soil
LEAST RESILIENT STATE
RT2
RT1
RT4
RT3
Arrows represent process pathways
(explained below)
RT6
RT8
RT7

RT1 - RT4 = loss of vegetation and erosion resistance

RT2 - RT3 = loss of beaver, some water supply, some vegetation

RT4 - RT6 = Incision, loss of most of the water supply

RT3 - RT6 = loss of dams, Incision, loss of water supply

RT6 - RT7 = major lateral channel movement, loss of soil

RT7 - RT8 = Slow accumulation of fines, pioneering plants of the change at this point in the description is not considered, rather, the understanding of the process mechanisms is the main concern. After process pathways are identified they can be related to potential causes of the change. For example, a process pathway may be the change in groundwater gradient because of channel deepening. Subsequent determination of potential causes of the deepening can be worked into the site description or other management guidance.

Incorporating the Hydrologic Processes

As discussed above, it is believed a riparian classification and/or site description should include sufficient process information to help determine cause and effect as well as management options. As a minimum, the following information should be included in the classification description (details are given later):

1. Description of substrate and soil (streambank, channel bottom, and floodplain), including profile descriptions and erosion resistance.

2. Relation of various discharge amounts to channel capacity and function.

<—

Figure IV-8. Concept of state, state change and process pathways. States shown as riparian type (RT1-8). Each state respresents a potential environment for a site that is spatially fixed. State RT1 could represent an active, ecologically well-balanced valley depositional. It is not considered vulnerable because of dense willow cover. State RT2 could represent an ecologically well-balanced beaver-dominated system. Its environmental condition is not too vulnerable to change since the beaver/vegetation combination offers good protection and excellent recovery potential from most environment-altering conditions. RT3 could represent a remnant of RT2 without the beaver. It is still resilient but is highly vulnerable to further change. Loss of dams is probable. State RT4 is a stressed, possibly overgrazed condition of RT1. Its resiliency is high; however, its vulnerability is much lower because of the reduction in willow cover. State RT5 is the beginning of incisement phase of RT6, but there are significant amounts of vegetation and substrate remaining. RT6 represents major entrenchment. Soil water regime is severely altered. Bank vegetation no longer will survive. State RT7 is the most severe change resulting from lateral channel migration. It is no longer considered vulnerable since the site has changed to very coarse channel material. Recovery to state RT8 is low without assistance from the beaver or other structural means.

3. Description of the general flow regime during the year, including the type of source, persistence, and other behaviors thought to be important.

4. Description of ground and surface water behaviors typically encountered on the site through its range of states.

The following sections present detail on the above four recommended subjects for inclusion in a riparian classification site description. An example follows the section. The process section of this paper presents some basic discussion that may be helpful in identifying behaviors and developing narrative description. It is important that the narrative be as relative (not absolute) as possible to the general nature of the site, particularly in discussion of flows, to allow more meaningful extrapolation to similar areas (e.g. discharge as it relates to the position of the water column in channel, rather than a discharge rate).

Substrate and Soils

In this section, substrate is defined as rock and soil material that resides within the riparian site, channel bed and banks. Soils refers to the surface two meters or so of substrate that is generally capable of supporting vegetative growth. Descriptions should include:

Graphic of basic cross-section of valley (normal to the valley) including estimated layering of substrate and general texture where definable, particularly about 3 meters above and 2 meters below the existing channel bottom.

Information on bank composition and structure (e.g. cohesive, noncohesive, composite).

Estimated potential effectiveness of vegetation in controlling erosion on the banks and floodplain.

Discharge and Channel Capacity

Channel capacity as discussed in this paper refers to the position of water stage (i.e. surface water elevation) in the channel at various discharges. A totally full channel is called bankfull. Discharge at or above bankfull capacity assumes overbank flow (flow on floodplain). Descriptions should include the typical position of the water stage in the representative channel cross-sections for discharges equivalent to 1-year, 3-year, 5-year, 10-year, and 50-year flood occurrence and average annual minimum flow.

Flow regime

The flow regime description should include a representation of streamflow throughout the year including average and extreme conditions and the likely behaviors that control them. Descriptions should include the following:

1. Typical periods and explanations of extremes should be given (e.g. winter rain on frozen ground, late summer rain on hydrophobic soils).

2. Sources of the water and their persistence should be described in terms of where the sources originate (i.e. within or outside of the riparian system) and their distribution or concentration relative to the stream (i.e. discrete as in springs, geysers, seeps, or lateral as in seepage sources along the stream). Persistence of the sources is described in terms of their capability to provide water throughout a growing season or beyond. Other behaviors should be described such as reservoir operation and man-induced or unusual flow modifications.

Surface and Groundwater behavior

These are descriptions of the behaviors responsible for the soil-water characteristics of the sites and their states. These may include groundwater energy gradients, capillarity, surface and subsurface hydraulic controls, channel, bank and floodplain interaction, and water-holding capacity of substrate. Process explanations are presented later.

Example Application

The above-recommended information is an ideal request. It is very difficult to determine many of the descriptions with certainty and we are not suggesting that field investigators spend an inordinate amount of time or money completing a description. However, we are convinced that experienced investigators can make estimates that are reasonably accurate, commensurate with the accuracy of most classification efforts, that will give the user hydrologic process information and a clearer understanding of how and why a riparian system operates.

The following example presents what might appear in a riparian classification description that has been integrated with hydrologic process information. This example presents a lot of information, much that is directed towards management. Obviously descriptions could be expanded in subject areas of particular importance.

Riparian Type Name: Quaking aspen/willow type - fluvial canyon, depositional.

Location and Landform: Elevation range of 1200 through 2100 m. Typically occurs alluvial and colluvial surfaces adjacent to streams.

Stream Type: Closely represented by a B4 stream type (Rosgen 1985). Gradients typically near 2 percent, sinuosity between 1.5 and 1.9, channel material gravels, sands, some cobble. Upper bank, fine cohesive. Typical cross-section shown in Figure IV-9a. Narrow and deep channel, well to moderately confined.

Vegetation: This type is dominated by a quaking aspen overstory and an understory of dense willow and other shrubs. Graminoids include bluejoint wheatgrass, Kentucky bluegrass, fowl mannagrass. Diverse forbs may be present, including northern bedstraw, common horsetail. Seral stages can include much reduced density and reproduction of quaking aspen and shrubs due to heavy grazing.

Soils: Soils are usually fine-grained overlying coarser cobbles, gravel, and sand. Upper layers range from well-sorted clay soil to a mixture of gravel and fine grained material. Typically the fine-grained soil thickness is less than 1 meter.

Water Regime: Most precipitation occurs in the winter and accumulates as snowpack, particularly on the northern slopes due to topographical location and vegetation. Average annual floods and larger floods associated with more controlled snowpack melt or rain can be affected by the amount of vegetation cover on the watershed. Based on current channel geometry measurement, average floods are in the range of 150 cubic feet per second per square mile. Most sites are characterized by local, lateral, and persistent (easily lasts a growing season) inflow on north slopes.

This is due to a large accumulation of fine material providing sufficient storage to capture much of the winter snowpack. South slopes rarely have persistent inflow. Soil moisture on the northern side of the channel is maintained mostly by groundwater flow gradients towards the stream with some effective capillarity near the northern streambank. Soil moisture on the southern streambank is maintained almost exclusively from longitudinal gradients accentuated by instream hydraulic controls and/or capillarity.

States: Common states include an entrenched condition, beaver dominated condition, and a severe, laterally eroded condition (Figures IV-9b-d). The entrenched condition will vary but generally as normal stage drops below the interface of the fine/ coarse material, capillarity may become ineffective, the annual flood may no longer provide overbank flows reducing bank/ floodplain recharge efficiency. Severely entrenched systems may lead to removal of fine materials. Vegetation may change, particularly on the southern bank, to species tolerating drier conditions, such as sagebrush. North side vegetation may not show significant change because of the persistence of the water source unless the disturbance factor from overbank flooding is important in species propagation.

The beaver dominated state will change much of the vegetation character to an open water type and may aggrade several meters. Post-beaver stream channels will have fine-grained channels and terraces. Capillarity will have a greater role in maintenance of soil-water levels. Incised states of beaver dominated sites will have more pronounced soil-water decline since soil-water source is more dependent on the stream than in the lower elevation states.

The most severely altered state of this site would be where fines are removed, through lateral channel migration, leaving only coarse substrate.

State change: Loss or significant reduction in willow and other shrub cover greatly increases the site's susceptibility to incision. Loss of instream hydraulic controls (e.g. pool/riffle complex) may result in drier upperbank conditions, increasing potential of significant bank erosion and channel widening, including lateral migration. Change to beaver dominated state is almost certain with viable populations of beaver and adequate woody vegetation.

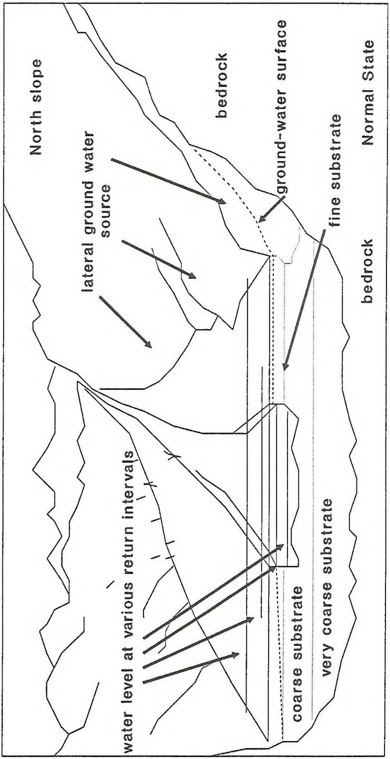

North slope
lateral ground water source
bedrock
ground-water surface
Normal State
fine substrate
bedrock
water level at various return intervals
coarse substrate
very coarse substrate

Figure IV-9a. Quaking aspen/willow type - fluvial canyon, depositional state, typical cross-section. Approximate stage with flood return interval is shown.

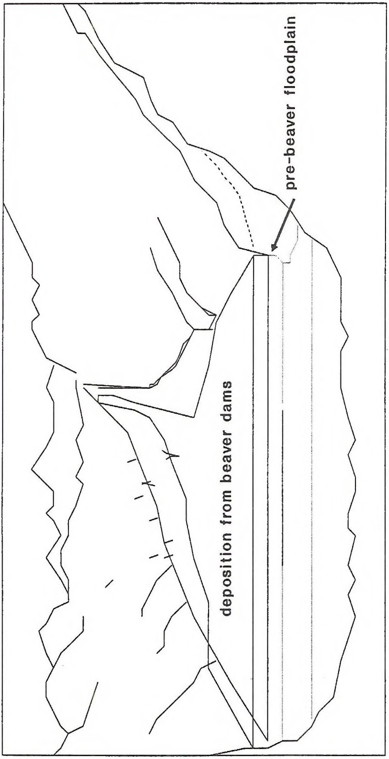

pre-beaver floodplain
deposition from beaver dams

Figure IV-9b. Beaver-dominated state.

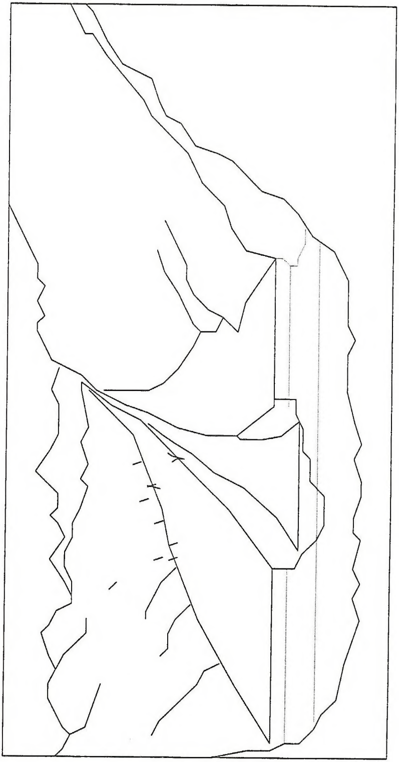


Figure IV-9c. Entrenched state.

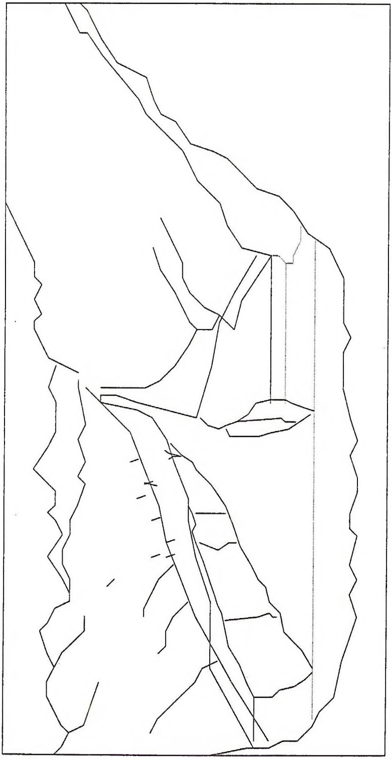


Figure IV-9d. Laterally eroded state.

Adjacent Communities: Wetter sites are dominated by carex (e.g. beaver dominated state), drier sites by spruce, sagebrush, or Idaho fescue.

Management: Forage production varies from low to moderate depending on the density of the shrub layer. This site type is preferred by livestock because of shade, shrubs and trees for scratching, and a variety of palatable species. Wildlife use can include beaver, deer, elk, and a large number of bird species. Fisheries habitat is often greatly enhanced by the presence of overhanging vegetation. Undercut banks are common because of the increased stability offered by the shrubby vegetation. Fire and other disturbance may be important in maintaining the site's type. Soil compaction is likely on site. Trails may provide concentration points for water, increasing chances for headcuts. This type is not considered vulnerable while in dense vegetation and is resilient since the water supply is persistent and soil has good water holding characteristics and is adequate in depth (erosion occurs but at rates and magnitudes that can be tolerated by the site). This type is very vulnerable to state change when shrubby vegetation is reduced because of the erodibility of the fine material. The most severely altered state of this site would be where fines are removed, through lateral channel migration, leaving only coarse substrate. The water source, though persistent, would have poor quality soil and recovery from this altered state would be very slow without assistance from beavers or artificial means.

Determination of Wetlands, EPA-COE Manual

The EPA and Corp of Engineers administer the Section 404 program of the Clean Water Act. EPA, COE and SCS have produced the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands," which offers technical guidance on what is or is not a wetland depending on characteristics of vegetation, soils, and hydrology.

Riparian areas are not specifically addressed under the 404 regulations; however, many riparian areas possess the characteristics of wetlands and therefore should be considered as such in their management. The COE and EPA consider wetlands,

> *"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support,*

> *a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."*

For wetland determination, an area must possess characteristics described by technical criteria in all three categories of vegetation, soils, and hydrology. For vegetation, one main criterion requires an area to be dominated by 50 percent composition in obligate wetland, facultative wetland, and/or facultative species of vegetation. For soils, the criteria used are those established by the National Technical Committee for Hydric Soils. For hydrology, the criteria are described below.

An area has wetland hydrology when saturated to the surface or inundated at some point in time during an average rainfall year, as defined below:

1. Saturation to the surface normally occurs when soils in the following natural drainage classes meet the following conditions:

a. In somewhat poorly drained mineral soils, the water table is less than 0.5 feet from the surface for usually one week or more during the growing season; or

b. In low permeability (<6.0 inches/hour), poorly drained or very poorly drained mineral soils, the water table is less than 1.5 feet from the surface for usually one week or more during the growing season; or

c. In more permeable (>= 6.0 inches/hour, poorly drained mineral soils, the water table is less than 1.0 feet from the surface for usually one week or more during the growing season; or

d. In poorly drained or very poorly drained organic soils, the water table is usually at a depth where saturation to the surface occurs more than rarely. (Note: Organic soils that are cropped are often drained, yet the water table is closely managed to minimize oxidation of organic matter; these soils often retain their hydric characteristics and if so, meet the wetland hydrology criterion.)

2. An area is inundated at some time if ponded or frequently flooded with surface water for one week or more during the growing season.

In addition to the above, the manual gives some direction on disturbed and problem area wetland determination. Disturbed area determinations are to provide evidence that a wetland occurred or did not occur previously to disturbance and of whether wetland hydrology still exists. Problem area wetlands are those where disturbance has not occurred but the site has undergone some type of change (e.g. beavers) that may not allow for all of the three wetland characteristics to manifest themselves.

In dealing with determination of past wetlands, particularly those considered disturbed, it is important to have your jurisdictional authority interpret how past wetlands are to be included in a determination. (For example, if a disturbance occurred before the date of the jurisdiction, a wetland determination may not apply). Many or all of the indicators may have to reconstructed based on past accounts, historical data, and the application of models.

Examining the Wetland Hydrology Criteria

Based on the criteria provided the following conditions must occur:

An area must be saturated to the surface or be inundated usually for one week or more during the growing season during an average rainfall year (except in the case of organic soils).

The key parts of the criteria are "saturated to the surface," "usually for one week or more during the growing season," and "at some point of time during an average rainfall year."

Included in the criteria are general depths to a water table for three drainage classes of soil that normally produce saturation to the soil surface. These are shown below.

Description of Soil Drainage	Depth to Water Table
Somewhat poorly drained	< 0.5 feet
Poorly drained or very poorly drained; permeability >= 6.0 inches/hour	< 1.0 feet
Poorly or very poorly drained; permeability < 6.0 inches/hour	< 1.5 feet

While no technical background for the establishment of these guidelines is given, it can be assumed that these gross characterizations of drainage and the depths to water table is an attempt to define a limit of effective soil capillarity providing apparent saturation to the surface. The term apparent saturation is used here to distinguish from true saturation, where all effective pore space is filled with water. The definition of saturated, given on page 73 of the manual, is consistent with this. However, under a capillary condition, all pores may not be saturated although the soil may produce water upon squeezing. This may appear to be a trivial difference but could be important in producing or not producing anaerobic conditions required in hydric soils. Such conditions might be seen in soils possessing variations in pore size as in soils with poorly sorted texture.

Field Determination

The major challenge of the wetland hydrology portion of the manual is the great deal of variation in conditions found in the field, particularly in the usually brief amount of time one spends making a determination. It is important then to utilize the time in the field wisely and to make interpretations based on ambient conditions correctly interpreted for other periods during the year. In some cases, interpretation may be based on a few field observations coupled with historical data and physical principles discussed earlier.

Rosgen's Stream Typing

Rosgen (1985), presents a stream classification based on morphological characteristics of streams. The Rosgen system identifies streams based largely on gradient and the composition of streambed and banks, although important characteristics also include sinuosity, confinement and entrenchment, and form factor (width-depth ratio). The utility of the Rosgen system is in its simple categorization of streams having similar characteristics. Basically the classification uses an alphanumeric identification. The alpha ranges currently from A to C (steep gradient to flat gradient), D types (those that are braided), and F types (those that are deeply incised). The numeric portion of type describes predominately bed materials, from bedrock to fine grained substrate, 1 to 6, respectively. The final stream typing in its simplest form appears as A1 for steep, bedrock controlled channels, B3 for moderate gradient, coarse channels, C5 for flat, fine grained stream, etc. Rosgen (1985) presents no field data to substantiate the delineations; however, it is clear that the system is based on significant field examples. It is also pointed out that the system may be a first approximation of what is likely to be refined over the years. The beauty of the system is that it provides a simple tool to help in the visualization of a common reference point not unlike classification systems for geology, rocks, vegetation, and animals. The system also provides a relatively easy means of gaining a description since many of the characteristics are easy to obtain.

Some may question the validity of the Rosgen classifications and not without basis, since the system was somewhat undocumented. During the past year or two I have been documenting the accuracy and utility of Rosgen's system on many streams throughout the West. I have found that the Rosgen system, with few exceptions, appears to represent stream segments with reasonable accuracy. Those using Rosgen's system are advised to collect accurate field data. Without this data, the Rosgen system cannot be adequately verified, refined, or perhaps simplified. The remainder of this section is devoted to a discussion on the physics and mechanics of Rosgen's system.

Figures IV-10 and IV-11 represent graphical representations of Rosgen's system for width/depth ratio (form factor), gradient and substrate, and sinuosity, respectively. The first two attributes can be related to velocity, stream power, and sediment size by relating form factor to hydraulic radius for several given sizes of streams.

Figure IV-11was modified as shown in Figure IV-12 using critical shear stress estimates (Shields 1936 as cited in Vanoni 1975). Velocities were estimated using the Manning's equation. The latter two figures indicate that many of the classes described by Rosgen appear to be supported by state equations.

Rosgen's system can be a first cut attempt at stratifying streams into categorizes of similar behavior. Using Rosgen's system in concert with vegetation classification can result in powerful stream management tools.

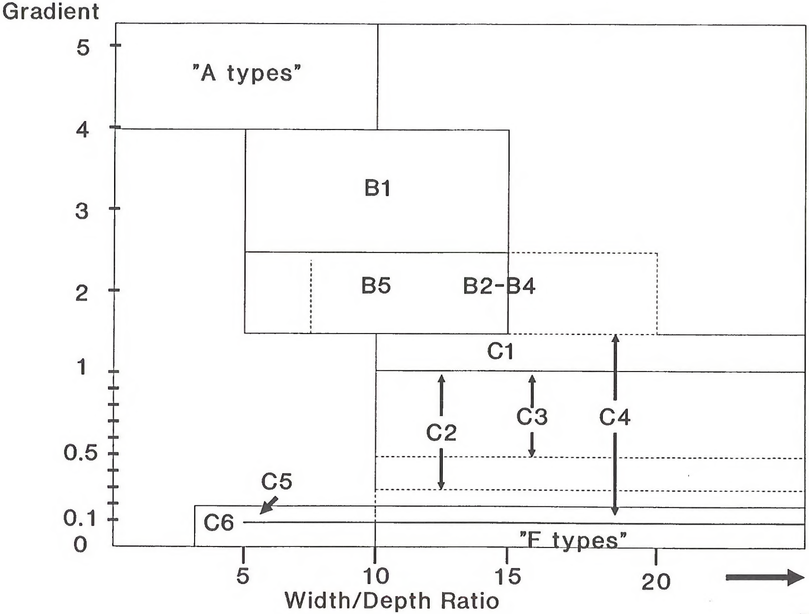


Figure IV-10. Display of Rosgen's system with gradient and width-depth ratio.

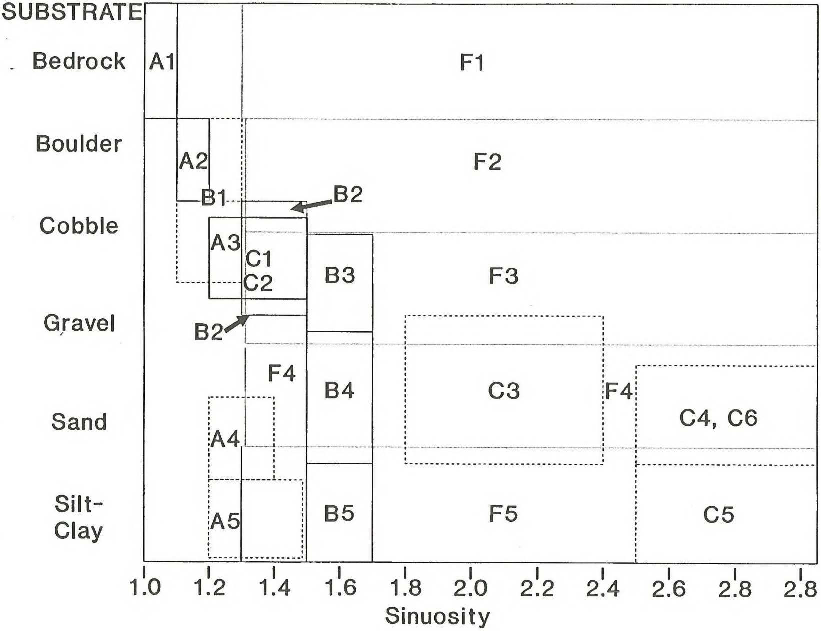


Figure IV-11. Display of Rosgen's system with substrate and sinuosity.

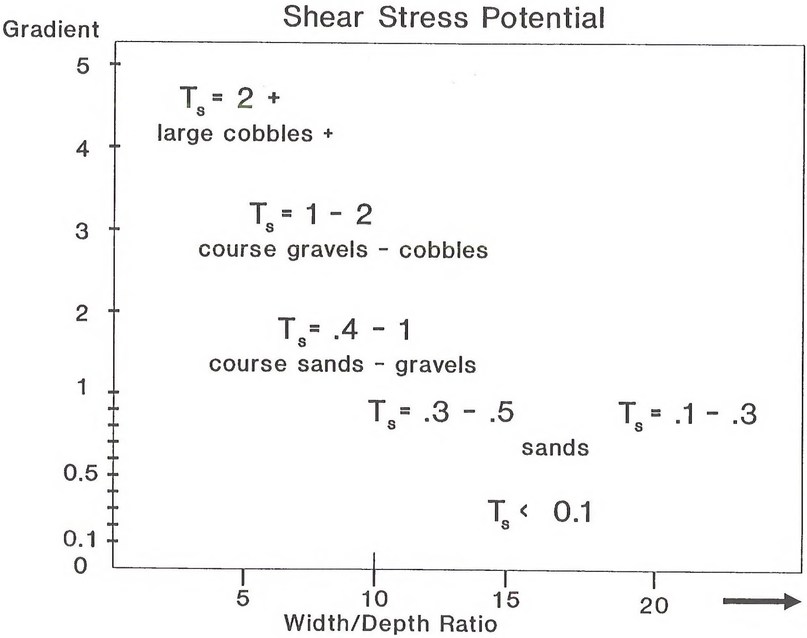


Figure IV-12. Display of Rosgen's system with gradient and width-depth ratio in relation to shear stress potential.

Checklist for Evaluating Projects and Best Management Practices

Best Management Practices (BMP's) are simply common sense practices to reduce the chances of pollutants from impacting a water of concern. This section does not list a number of BMP's; rather, major processes that BMP's attempt to regulate will be discussed. If the field regulator can recognize the pathways of pollutants, he or she will likely be able to estimate if the particular practice will be effective or not. An ineffective BMP in reality is no BMP at all.

Alternative Practice

Avoidance of a practice that might cause problems is a key practice. This might include using one type of construction method, a non-toxic rather than a toxic, avoiding soil disturbance, etc.

Proximity to Conveyance points

Generally the farther a nonpoint source is from a conveyance point, the lower will be the potential for impact. Conveyance points are zones that usually have seasonal water transport capable of moving a pollutant. They would include such things as perennial, intermittent, and ephemeral channels, shore lines, recharge areas; areas of extremely low permeability in the case of surface water sources, such as parking lots, bedrock; areas of extremely high permeability in the case of groundwater, such as gravel pits, porous basalt, highly fractured bedrock, and wells.

Filtering Effectiveness

Between the source and a conveyance point is an intermediate transport zone. This zone is the area where nonpoint sources are minimized, usually through the filtering, physical obstruction, or delaying of pollutant transport. A key in evaluating many BMP's is determining the effectiveness of the filter area. The filter area has a limited range in which it will operate effectively determined by the rate of flow (depth of transport) over and through the filter (detention time), the size and nature of the pollutant (sediment versus salinity versus oil and grease), and the storage provided by the filter area. Filter areas are not limited to the surface. Subsurface obstruction, substrate conductivity, chemical and physical holding ability all are important in retarding or preventing nonpoint pollution from being transported. The effectiveness of these factors determines the frequency and length of time in which the BMP is likely to work (or not to work).

Drainage Control

Similar to filtering, is the control of surface and groundwater through or around potential nonpoint sources. The purpose of drainage control is to minimize or eliminate water from contacting the potential pollutant. Failure to do this greatly increases the likelihood of pollutant transport. Proper drainage design also minimizes indirect problems, such as erosive flow, significant temperature changes, or transport of other non-target pollutants.

Boundary Layer Control

Where a transport medium, such as water and/or wind cannot be prevented from contacting a nonpoint pollution source, it may be possible to modify the source to reduce transport. This is done through manipulating the surface/subsurface boundary layers to minimize the transport ability of the medium. For example, wind fences have been used for years to control the movement of snow, additives have been used to bind the pollutants together making them too large for transport, or vegetation or other materials can be used to increase the resistance of the boundary layer.

Solar Radiation Control

Increasing or decreasing solar radiation may have significant positive or negative effects on a particular nonpoint source. In the case of volatile organic increasing solar radiation may deactivate the pollutant. In the case of streamside habitats, increasing the solar radiation may destroy the fishery. Each potential pollutant should be examined as to the effect of solar radiation on its toxicity.

Instream structures and channel modification

Regarding instream structures and channel modification, an on-the-ground assessment should be done before finalizing any plans. The questions at right, when properly analyzed can eliminate most alternatives that will prove to be disastrous. These questions can also be used with Rosgen's stream typing in creating a list of BMP's by specific stream type.

What is the structure supposed to do?

What will the flows look like at high flow?

What is the likelihood that some foreign object will change the hydraulics of the structure? (Also consider structure stability.)

What is the streambed likely to do?

How will the streambanks respond?

How will the riparian water supply change?

What happens if the structure fails?

How dynamic is the structure?

The following table represents an example of nonpoint source severity rating that can be done by field personnel. This exercise helps to gain an understanding of what activities are likely to be most disturbing.

Table IV-8. Estimated severity of various nonpoint source pollutants and their respective

Nonpoint Source	Nutrients	Temperature	Salinity	Sediment	Turbidity	Bacteria	Aesthetics
Agriculture							
Non-irrigated crop	L		M	L			
Irrigated crop	H	H	H	H	H		H
Specialty	L			L			
Pasture	L	H	H	L	L	H	
Rangeland	L	H	L	H	M	M	L
Feedlots	H	L	L	L	M	H	H
Aquaculture	H	L	L	L	M	H	H
Animal holding	H	M	L	L	M	H	H
Silviculture							
Harvesting	H	H		H	H		M
Reforesting	L			L			
Residue	H			M	M		L
Road Construction	M	H		H	H		H
Construction							
Roads, bridges	M	H	L	H	H	L	L
Land development	H	H	M	H	H	M	M
Urban							
Storm return	H	H	L	M	H	H	H
Mining							
Surface	M	H	H	H	H	L	H
Subsurface	L	L	M	L	L	L	L
Placer	H	H	H	H	H	M	H
Dredge	H	H	H	H	H	M	H
Oil and gas	L	L	M	L	L	L	L
Mill tailing	M	M	H	H	H	L	M
Mine tailing	H	M	H	M	H	L	M
Land Disposal							
Sludge	H				M	H	H
Wastewater	H	H	H	H	H	H	H
Landfills	H		H	M	H	M	H
Hazardous	L	L	L	H	M	L	L
Hydrologic/Habitat Modification							
Channeling	H	H	H	H	H	M	H
Dredging	H	H	H	H	H	M	H
Dam construction	H	H	H	H	H	L	H
Vegetation removal	M	H	M	H	H	L	M

sources. (H= high, M= medium, L= Low, blank= very low)

Ph	Odor	Oil & Grease	Diss Gases	Diss Oxygen	Toxics	Insecticides	Herbicides	Metals	Peak Flow	Low Flow	Channel Shape	Channel Pattern
						M	M		L			
				M		H	H			+		
						M	M					
				M		M	M					
						L	L		M		H	
				H								
				H						+		
				H								
				H		L	L		H	M	H	
						L	L		+	+		
		L		H							H	H
		H		M	H	L	M	H	M		H	H
L		H		H	H	M	M	H	H	L	H	H
L		H		H	H	H	H	H	H		L	M
H	M	L		H	H	L	L	H	M		L	L
M	L	L		L	M	L	L	M	L	M		
H	L	M	L	H	H	M	M	H	L	L	H	L
H	M	H	L	H	H	L	L	H	L	L	H	M
L	M	H	H	M	M	M	M	L				
H	M	M	L	M	H	L	L	H			M	M
H	L	L	L	M	H	L	L	H			H	H
M	M			H	H	H	H	H				
H	H	M	M	H	H	H	H	H				
H	M	M	L	H	H	H	H	H				
		M		L	H	H	H	H				
H	M	H	L	H	H	L	L	H	L	L	H	H
H	M	H	L	H	H	L	L	H	L	L	H	M
H	L	M	H	H	L	L	L	L	H	H	H	H
L		L	L	M	L	L	H	L	L	L	H	M

METHODS

MICROFISH 3.0

INTRODUCTION

MicroFish is a computer software system that processes electrofishing data obtained by the removal method (Van Deventer and Platts 1989). MicroFish consists of programs written in the BASIC language (compiled using MircroSoft Quick BASIC 3.0) and is functional on all IBM personal computers and compatibles using DOS 2.0 or higher. Detailed procedures for running MicroFish are found in Van Deventer and Platts (1989). If you have any problem following these abstracted directions reference back to Van Deventer and Platts.

The software includes:

MicroFish Interactive Program - This program (MF.EXE) calculates maximum-likelihood population estimates based on user input of fish capture data.

MicroFish Statistical Package (Output: Table Format) - This package of subprograms (MFISH.EXE) calculates maximum-likelihood estimates and a series of fisheries statistics including capture probabilities, lengths, weights, and biomass.

MicroFish Statistical Package (Output: Database Format) - Performs the same calculations as the preceding package, except that output is in database format instead of table form.

MicroFish Sample Size Program (2 Dimensions) - The two-dimensional graph displayed by this program (MF-SS2D.EXE) indicates the number of electrofishing passes needed to achieve a desired level of precision. Computer graphics capabilities are required.

MicroFish Sample Size Program (3 Dimensions) - The three-dimensional graph displayed by this program (MF-SS3D.EXE) provides a conceptual foundation for the interrelationships among population size, catchability, electrofishing passes, and precision. Computer graphics capabilities are required.

An example of and a computer test in running the MicroFish program is:

1. Type: MF<enter>
2. Strike any key to continue
3. Type: Salmon River <enter>
4. Type: Rainbow Trout <enter>
5. Type: 4 <enter>
6. Type pass catches: 124<enter> 61<enter> 35<enter> 14<enter>
7. Type 0

Output results should be identical to:

```
Stream:  South Fork Salmon River
Species: Rainbow Trout

Removal Pattern: 124 61 35 14
Total Catch     = 234
Population Estimate  = 249

Chi Square        =   0.675
Pop Est Standard Err =   6.164
Lower Conf Interval  = 236.858
Upper Conf Interval  = 261.142

Capture Probability  =   0.501
Capt Prob Standard Err =   0.035
Lower Conf Interval  =   0.432
Upper Conf Interval  =   0.570
```

The output tables can be displayed by:

1. Type: MFISH<enter> (title page should show)
2. At each pause strike a key (4 times)
3. Type: MF-TEST.DAT<enter> (test data file)
4. Type: 1 (sends output to screen)
5. Type: 0 (to exit)

The output results data base format can be displayed by:

1. Type: MFISH-DB<enter> (title page shows)
2. At each pause strike a key (4 times)

3. Type: 1 (run one data set)
4. Type: MF-TEST.DAT<enter> (test data file)
5. Type: 1 (send output to directory)

The example MicroFish sample size program (2-D) can be displayed:

1. Type: MF-SS2D<enter> (calculations displayed)
2. Strike any key (to continue after graph displayed)
3. Type: n (to exit)

The example MicroFish sample size program (3-D) can be displayed:

1. Type: MF-SS3D<enter> (calculations displayed)
2. Strike any key (to display graph)
3. Strike any key (to continue)
4. Type : n (to exit)

To operate and input your fish population statistical data:

1. Enter stream and species names when called for
2. Answer yes or no questions on printing
3. The programs MFISH.EXE AND MFISH-DB.EXE require three sets of data input: (1) a fish file called MF-FISH.DAT containing numeric codes and fish names; (2) a parameter called MF-PARM.DAT that can be used to enhance program operation, including detection of data errors; and (3) one or more fish capture data files named by the user. MFISH.EXE allows only one fish capture data file; MFISH-DB.EXE can process mulitple files simultaneously.

Data files may be created with whichever line editor, text editor, or word processor you have at your disposal. The data files must be saved as DOS text files (ASCII files).

MF-FISH.DAT file should be created to contain numeric codes that identify fish species. Each numeric code is followed by a comma and then by the actual fish name. MF-FISH.DAT currently looks like this:

```
1, Salmon: Chinook
2, Trout: Rainbow
3, Trout: Brook
```

4, Trout: Bull
5, Trout: Cutthroat
6, Trout: Brown
10, Sucker
11, Sculpin
100, Whitefish
101, Dace

The fish species code must be a whole number from 1 to 1,000. The maximum characters in the species code is 16. The file can be modified to fit the species you are collecting.

Setting up Fish Capture Data

First Line of Data - contains information to distinguish this data set from your other data sets. The data will appear in table form output (from MFISH.EXE), but not in data base files created by MFISH-DB.EXE.

After the header record, subsequent lines of data pertain to captured fish. If individual fish are weighed and measured during electrofishing, then each line (record) in the data set corresponds to an individual fish. Generally, five variables are expected on each line of data. If no fish are caught on an electrofishing pass then only three fields are required.

Variable 1. The Site Number -

This is the number of the site where the fish was captured. It must be an integer from 1 to the maximum number of sites in sequential order, do not skip numbers. For example if only one study site is being analyzed in the data set, then the number 1 must be present throughout the length of the data file. If three study sites were electrofished, then MicroFish expects the numbers 1, 2, and 3 to be present somewhere in the first column of data.

Variable 2. The Electrofishing Pass Number -

If four electrofishing passes were made, then this number would be a 1,2,3, or 4, depending on which electrofishing pass the fish was caught.

Variable 3. The Species Number -

A species number is entered here to identify the fish captured. If no fish were caught on the electrofishing pass, enter a 0 for species number and leave the remaining variables blank.

Variable 4. The Fish Length -

Any units can be used for length and weight, but condition factors will be valid only with millimeters for length and grams for weight, the way the program is set up.

Variable 5. The Fish Weight -

Grams are expected if a value exists. This variable can be left blank.

Variable 6. The Total Number of Fish Captured -

If this option is used then variables 4 and 5 *must* contain periods instead of length and weight measurements. The periods signify missing values.

Variable 7. The Total Weight of Fish Captured -

If this option is used then variables 4 and 5 *must* contain periods instead of length and weight measurements. If neither group weights nor individual weights were taken then put a period in the place of variable 7.

The following examples illustrate the four allowable types of data lines not counting the header record.

```
Line 1 ---   1    1    3   100    15.1
Line 2 ---   2    2   10     .       .    3   16.8
Line 3 ---   3    2   11     .       .    2     .
Line 4 ---   3    4    0
```

<u>Line 1</u> - Identifies a fish captured from study site 1 on the first electrofishing pass. The species number of 3 indicates from file MF-FISH.DAT that a brook trout was captured. The fish was 100 millimeters in length and weighed 15.1 grams.

Line 2 - Refers to a group of fish captured. Note that variables 4 and 5 contain periods indicating missing values because no individual fish were measured. This group of fish was captured from study site 2 on the second electrofishing pass. Species number of 10 refers to suckers. Three suckers were captured with a group weight of 16.8 grams.

Line 3 - Identifies fish captured in study site 3 on the second electrofishing pass. Species number 11 refers to sculpin. Two fish were captured. No group weight was taken.

Line 4 - Represents a special situation. In study site 3 on electrofishing pass 4 no fish were captured. In such cases a zero should be entered for the species number. No length and weight information should be entered. A species number of zero is the only species number that will not have a corresponding species name in the file of fish names. This special record type is only required when no fish are caught in the entire study area on the last of a series of removals. The zero signals MicroFish how many electrofishing passes (4) were made.

Cautions

All variables need to be separated by at least one blank space (or a comma, or both). Do not put blank lines in the data.

The program is not capable of performing calculations on a data set in which a single species has a mixture of individually weighed fish and fish weighed in groups. Species A may have grouped measurements and Species B may have individual fish measurements in the same data set, but don't mix individuals and groups within the same species.

The same number of electrofishing passes must be made at each site in a data set. The largest electrofishing pass number in the data is assumed to be the number of passes at each site.

Program Outputs

MFISH.EXE is capable of outputting fisheries population estimates and statistics in tabular form to the screen, to a line printer, or to a data file. MFISH-DB.EXE creates output data files only. MFISH-DB.EXE describes the output format.

All MFISH-DB.EXE output results are automatically given a ".RES" file name extension. For example, if a file named FISH1988.DAT is used as input then the results file will be labeled FISH1988.RES.

MFISH-DB.EXE allows one to process several data sets at once or one at a time. If processing serveral data sets, a file must be created containing a list of data file names.

MicroFish Sample-Size Programs

The sample size software programs MF-SS2D.EXE and MF-SS3D.EXE answer the question of how many electrofishing passes are required to yield desired levels of precision in the maximum-likelihood population estimate. The first program shows sample size relationships among population size (N), precision (P), number of electrofishing passes (T), and CP(N) in two dimensions (2-D). The second program does this in 3 dimensions.

To print the graphs from the computer screen, one must type in the word GRAPHICS (a DOS command) *before* running the program, then press the Print-Screen key once the graph is displayed.

MF=SS2D.FIL OR MF-SS3D.FIL will automatically read a proposed sample size program each time it is run. The following is an example of a program run:

```
50  350   50
30   70    5
 2    6    1
50    1   10    1
 9    1    3    2    1
```

Line 1 sets the range of population estimates from 50 to 350 in increments of 50. Line 2 sets catchability from 30 percent to 70 percent in 5 percent increments of 1 (two passes minimum are required).

Parameter 1 of Line 4 sets the maximum CP(N) at 50. Parameter 2 should equal 1 to display CP(N) scales, zero to suppress scales. Parameter 3 sets the number of increments to be made on the CP(N) scale. In the case shown above, precision levels up to

CP(N)= 50 will be shown in 10 increments (0,5,10....,50). Parameter 4 displays precision lines behind display bars if the parameter value is 1. These lines are suppressed if parameter 4 is 0.

On Line 5, parameter 1 sets the background color (text mode) for the axis labels. Parameters 2 through 5 set the color (graphics mode) for palette, graph background color, border color, and scale line color, respectively. Graphics mode colors range from 0 to 3.

The following is an example of MF-SS3D.FIL:

```
50  300   50
25   75    5
 2    6    1
50
 9    0    3
```

The MF-SS3D.FIL is exactly analogous, except that fewer adjustable parameters are present in line 4. Line 5 lists background color, palette, and line color.

To estimate electrofishing sample size it is necessary to make rough predictions of N and P and to choose a desired precision level. The likelihood of meeting precision goals during actual sampling will be increased if the estimates for N and P are conservative or lower than true values.

Sample size graphs are displayed with several groups of columns, one group for each population estimate. Each group of columns represents the range of catchabilities specified by the user. Find the most appropriate values N and P on the graph, then proceed vertically up the column until you reach the desired precision level listed on the left-hand axis. The color of the bar at that point indicates the number of electrofishing passes required to reach that precision level given the values of N and P. This is the number of electrofishing passes that should be made in the field.

CLASSIFICATION

INTRODUCTION

Classification of riverine-riparian habitats in the context of their surroundings provides an effective basis for resource assessment and management. To date, however, little progress has been made in developing a classification system for fisheries management purposes, i.e., a system that deals specifically with those habitat types and complexes in which fish survive. If fisheries managers are to fulfill their responsibilities as stewards, they must first know the type, condition, and capability of the waters they manage. They must know how the surrounding land uses, such as livestock grazing, mining, and logging influence the fisheries and how best to predict or mitigate adverse effects that may develop. Classification is the best analysis approach available for determining the compatible grazing strategy to fit a selected area of land. (Terms used in this section are defined beginning on p. V-24.)

To date, fishery resource evaluation has largely depended on intuitive thinking and undirected inventories. Inventory without classification is mainly an unorganized list with little temporal analysis capability. Streams and their valleys act as integrated units; therefore a stream inventory by itself leaves out needed understanding. Also, because streams and valleys differ over space and time, data, understanding, and interpretations cannot be transported from one area to another without a transporting mechanism. The reason why most models fail us today is because they have no mechanism to transport their use over space and time.

A riverine-riparian classification system has tremendous potential for researchers and managers. It can provide a common language and format for organizing complex systems for understanding. The classification system must be able to inventory, assess habitat condition and potentials, map, transfer experience over space and time, assess management scenarios, and identify and monitor "Best Management Practices." Hall and Knight (1981), however, state that no integrative, systematic approach exists for even understanding natural variability within and among streams and their communities. Many authors have stressed the strong need to develop classifications that will develop the linkages between terrestrial and riverine habitats (Cowardin et al. 1979, Platts 1980 and 1974, Frissell 1986, and Larsen in press).

The classification system presented in this chapter will identify regional to site areas of homogeneity and differences. Platts (1974, 1979) has demonstrated previously that terrestrial and aquatic systems could be integrated into one system. This work, and work by other authors (Frissell 1986, Lanka et al. 1987, Warren 1979, and Warren and Liss 1983), have shown that streams are controlled by the watersheds they help build, and reflect the hydrology, geomorphology, and biology of their drainage basins. Ninety-five percent of all landforms are sculptured by streams. Landform and stream development occur together (Strahler 1964). Consequently, there is conformity in their systems. Therefore, the opportunity exists to classify riverine-riparian habitats and open up areas of analysis and management that have never been available to us before.

This classification approach presents a hierarchical system that stratifies the variance inherent in riverine-riparian ecosystems and identifies homogeneous classes. The system integrates geology, hydrology, geomorphology, and biology to identify, describe and map riverine-riparian habitat to a complex level. Thus, each stream can be identified as to those multivariate controls and processes that form and type its ecosystems and as to those processes that exercise the most influence on habitat conditions and resulting fisheries. The most important product of this classification system is that it will identify states of systems. The method integrates the bio-physical and cultural controls on the system and embeds this information within the landscape so it can either function as a cumulative analysis or a site describer. The system will identify magnitudes and frequencies of controls and their sensitivity to ecosystem response. Thus, a means of not only determining, but predicting, system structure response is available.

CONCEPTS

Classification is a method of locating and arranging objects into groups and ordering these groups into similar compartments. Classification in a simplistic form identifies and labels similar kinds of things. In the strictest sense classification orders or arranges objects into groups or sets on the basis of their similarities or relationship to each other. Classification, as used in this document identifies, locates, orders, describes, predicts, and integrates at the same time.

In the classification literature, three distinct approaches are used to classify. One is broad-based and covers large areas of land (Bailey 1983 and Omernik 1987); the second is detailed and covers small pieces of land (Frissell 1986 and Platts 1974); the third uses concepts (Minshall et al. 1983). The classification method described here combines all three approaches and integrates them so it will be useful at all levels of generalization.

The main concept is that by grouping habitats from regions to site levels, similar riverine-riparian groupings reduce their overall variability and are ordered into workable units. Warren (1979) used much this same approach but did not keep it ecological at all levels. Frissell (1986) did an excellent job displaying this approach but left the ecological approach below the reach level.

Riverine-riparian ecosystems are not identified by individual ecosystem components nor should we attempt to manage them under this approach. The structure and function of these habitats are determined mainly by their surrounding watershed (Hynes 1972). Therefore streams draining and being controlled by similar upstream geomorphic processes and containing similar surroundings will be similar and have similar responses to an applied benefit or stress. This process-based approach is the key element in predicting response by identifying environmental attributes at each level of the hierarchy. Cultural activities can alter similar lands and streams and therefore must be accountable in the evaluation system. To date, few people have attempted to determine how natural and altered ecosystems respond to spatial patterns as identified by a classification system. The state of the art is far enough along, however, to show that this evaluation method has high chance for success and should be tested.

Lotspeich (1980) outlined a broad to low level classification system for aquatic habitats, based on natural attributes that he proposed for testing. Lotspeich and Platts (1982) identified climate as the master factor supplying energy and water to all ecosystems, while geologic elements (structure and lithology) supplied the material for landform development. Soil and vegetation in response to climate and geology integrate with water to produce the complexes. Larsen et al. (1986) tested a similar system in Ohio and found fish assemblages did correspond to this type of ecoregion distinction.

In concept, the local riverine-riparian complexes cannot be completely understood until they are put into context with their surroundings. Once put into context with an ecological approach, stresses or benefits can then be evaluated under a mix of components rather than attempting to tackle each component separately, as is so commonly done.

The concepts of this classification system require that:

1. The riverine-riparian ecosystem be controlled by casual forces.
2. Lands can be arranged by classes based on natural attributes and as modified by cultural effects after the attributes have been evaluated as environmental elements.
3. The system be hierarchial.
4. The system components be locatable and mappable.
5. The system expresses the interactive character of all controlling factors, and sometimes past controlling factors, that give structure to ecosystems.

OBJECTIVES

Any classification system must be driven by and must meet its objectives. A classification system allows more efficient establishment of monitoring stations, determines local land use impacts, is able to identify cumulative impacts and allows a more systematic interpretation of these relationships. A classification system must be able to assess the past and present, predict the future, and extrapolate this information over broad land areas. Very seldom has a classification system been tested to see if it can meet these objectives. In most cases, solid objectives have not been applied to allow hypotheses to be tested.

An important objective of this classification system is to provide a process that will determine if a land or water activity is in compliance with the NEPA process and the Water Quality Act of 1964, as amended. The process will allow assessment of nonpoint source impacts to riverine-riparian habitats. To do this the system must fulfill the following objectives:

1. Identify the existing state structure and function and their respective physical and biological processes.
2. Identify the natural state under today's sets of conditions and the variability of this state over time.
3. Estimate achievable state conditions and identify units of similar potential even though present states are not identical.
4. Determine the state direction (trends) in which the system is moving.
5. Determine the time intervals occurring between state changes under known applications of stresses or benefits.
6. Identify, apply, and monitor poor and Best Management Practices.
7. Determine limiting factors that determine the biotic carrying capacity for each state.
8. Transfer knowledge and experience over space.
9. Evaluate the influence of natural and artificial geomorphic-physical conditions within the watershed on the fisheries.
10. Determine attainability (as described in the Water Quality Act) of riverine-riparian habitats in a regional perspective.
11. Allow valid establishment of control and treatment sites for assessing nonpoint source impacts to riverine-riparian habitats.
12. Display and describe riverine-riparian habitats at selected hierarchical levels.
13. Identify those variables that are sensitive for identifying and assessing nonpoint source impacts (monitoring).
14. Be hierarchical and mappable.
15. Display the regional characteristics of riverine-riparian complexes and describe their inherent capabilities and potentials.
16. Be amenable to hypothesis or model testing.

MANDATES

Land and water managers must have tools for understanding their resources and initiating management direction to ensure compliance with existing state and federal law and regulations. Managing nonpoint source pollution, evaluating complex arrays of land uses, and designing and initiating stream riparian programs require cost-effective tools. An environmental synthesis must directly link processes to evaluate potential uses and, in the environmental impact assessment, display the possible effects of any development process.

Managers must have the necessary resource information to be able to abide by regulations relevant to the class of land and water being addressed. Public lands are governed by the Multiple Use and Sustained Yield Act of 1960, the Resource Planning Act of 1974, and the National Forest Management Evaluation Program and Resources Planning Act of 1980, and others. The NEPA process defines the national environmental policy to derive benefits while preserving and protecting the resource base. All lands, public or private, come under Section 208 of the 1972 Clean Water Act. The U.S. Environmental Protection Agency revised the Water Quality Standards Regulation (Federal Register 1983) which changes the direction state and federal management programs will go in the future. The new direction is toward "attainable water quality" which reflects directly to the fisheries and their habitats under the receiving systems analysis.

Any new classification tool must place habitat quality (water quality), hence watershed quality, into an environmental perspective, and be organized according to ecological regions to allow a proven process that will realistically reach feasible goals.

The classification approach presented here will provide methodology to assess the effectiveness of management in protecting and enhancing riverine-riparian habitats. The approach will also predict impending or potential land use impacts and trends in riverine-riparian condition. Cumulative effects assessments, a major recent concern of land and water managers, can be achieved by selecting the hierarchical levels that reflect the geographic area of concern. Broad levels of resolution may be estimated by grouping together the more discrete classes.

Different types of land use impacts, such as nonpoint pollution sources from livestock grazing, mining, and logging, can be expected to affect riverine-riparian habitats through various, often interrelated, or synergistic mechanisms; therefore, no single parameter can be identified for assessing impacts. Also, different riverine-riparian habitats will not respond in a like manner to the same stress or benefit. Consequently, the classification process must identify families of variables to be used for monitoring purposes. These families of variables will vary by the descriptive variables used depending on the type of use and type of impact. The family of variables to monitor livestock grazing would be different from the family of variables for monitoring a mining operation, although there may be some overlapping.

Most land management monitoring programs today rely primarily on the measurement of an assortment of physical and chemical parameters with little testing as to their value or how they relate to ecosystem processes. In other cases, often just one variable is monitored, such as site-specific embeddedness, which has little chance of success in describing land use effects. These approaches do not measure the physical continuity, or the biological integrity of riverine-riparian habitats. Also, it is dangerous to think that riverine-riparian habitats can be measured by water quality variables alone. In many streams of the West, chemical water quality condition has improved while fisheries habitat, at the same time, has worsened. Consequently, the approach must not only be integrative of the physical and chemical processes, it must also be ecological by treating each system as an ecosystem with all that it implies, by separating casual factors from the conditioning influence of biological resultants.

Integration

Integration is an essential part of classification because it allows the various components to be evaluated singly or in combination with other variables to better describe an interacting system. In this classification, the whole is the watershed and components are water, vegetation, channels, streambanks, soils, and fisheries. In a broader perspective, climate and geology are the independent driving components where all other components are dependent variables that determine the condition of the system. Integration must permeate the entire effort of the classification process, which is achieved by defining classes of the hierarchy in terms of the cause of differences between classes. Integration simplifies the process and allows a minimum of independent variables to be used in analysis.

Approach

The classification approach must describe the ecosystem processes that give form and productivity to the ecosystem (Lotspeich and Platts 1982), without attempting to describe each element constituting the system. The approach for this classification system is to delineate riverine-riparian ecosystems to reflect terrestrial factors controlling their character over time and space. Most presently used riparian zone classifications present only vegetation condition in its existing state. Vegetation often hides those conditions that are more important to the classifier, and actually supply the limiting factor.

The hierarchical structure used in this approach allows the lower levels of the hierarchy to be displayed with narrower sets of descriptive variables. It allows the integration of information from many sources. This allows the land manager to enter at any level requiring the least amount of time and effort for a particular use, while answering the manager's question. Thus, objectives can be met most cost effectively.

The approach hinges on the ability to describe the system by its existing state and controlling processes which are readily available from the accompanying descriptors. Another requirement is that either experience or natural control must be available to predict the natural state, if it doesn't already exist on site. In some areas, this can be much more difficult and more effort must be expended to meet this requirement. However, by using geomorphic reasoning based on processes that cause a given landform under a projected climate, a satisfactory estimate can be realized.

PROCESSES

Geologic

Geologic structures form the elevational gradient with its potential energy to which runoff responds and dictates the distribution of springs, lakes and the courses of rivers. Geologic processes largely define the way water handles sediments and nutrients in the fluvial continuum. These processes influence or control the elevation differences to which these geomorphic-hydrologic processes respond (the energy level of the system) to gravity and are key in integrating landform and inherent erodibility.

Climatic characteristics such as precipitation, evaporation, and temperature, further define the limits of weathering processes working with gravity to change gross geologic features into geomorphic form. Geology can be quite homogeneous as represented by the Idaho batholith or quite complex along changing types, such as a belt series. Geology is handled in the classification approach mainly at the higher levels. However, it is an independent variable at lower levels of the hierarchy by its control through lithological and structural control on soil and local landform.

Geology has much to do with the course followed by riverine systems due to its control of drainage patterns, the form they take, and the soils that border them. Therefore, stream network structure is already set by geology, and the three dimensional aspects of the system become apparent. Stream network and geologic topography are inseparable. In this classification approach geology quickly becomes identifiable in the upper hierarchical layers and its influence then trickles down through the layers because of its role as the parent material and its control of energy distribution by relief and gradient.

An example is the geologic influence and control in the upper Mary's River watershed in Nevada. Extensive areas of rhyolite have weathered to course-sand and cobble-size fractions, with scant gravel and fine-textured sediments. In contrast, areas of mixed rock types, such as the Independence Mountains, produce a preponderance of gravel and fine-textured sediments. The difference in the size distribution of weathering products has a pronounced influence on the geomorphic and hydrologic character of riverine-riparian habitat types.

Geomorphic

Land surface form results from geomorphic processes as influenced by interactions among climate, geology, vegetation, soils and land uses. Geomorphic processes include chemical and mechanical weathering, fluvial erosion, mass wasting and erosion, transport, and deposition. For example, U-shaped, V-shaped, notch shaped, concave, or linear valleys may all be formed, depending on dominant geomorphic processes. This concept is one of the most important elements used to develop this classification, because geomorphic processes control the manner in which water and sediment move through the watershed. This in turn has much influence on the structure and function of riverine-riparian ecosystems. The distribution of riparian vegetation and soils (which reflects prevalent climatic, geology and dominant geomorphic processes) is primarily a response to the geomorphic processes and how the combination of vegetation and soils conditions a watershed with respect to water movement within the basin by its texture.

Hydrologic

Climate is the driving force behind hydrologic processes that are difficult to separate from the geomorphic process because of their close interactions. Infiltration and runoff, coupled with the interaction between surface and alluvial groundwater, control stream corridors. Hydrologic mechanisms (an extension of geomorphic processes) influence riparian soils and, in turn, the condition of riparian communities. Permeability of the substrate, depth of bedrock or other impermeable substrate, and valley form influence water column form and permanency. Low flows are related to basin topography, climate, aspect, lithology, and valley soil properties and depths.

Alluvial discharge may be a major component of total discharge. This is a key item in this classification approach, because it's not the shape or the type of the channel or the condition of the surrounding vegetation that often determines fish productivity in the Great Basin. More often a more important variable to track is the shape and condition of the water column. A water column 1 centimeter in depth has a much different form in the same channel as a water column 3 meters in depth.

Alluvial aquifers however, are often the primary water source for riparian communities. Hydrologic-geomorphic processes building valley form and materials often determine stream and riparian structure and related function.

Interrelationships between stream stage and groundwater level may often be interpreted as a function of geomorphic valley form. For example, the coarse substrate characteristic of glacial valleys is conducive to rapid equilibration of groundwater and streamflow levels. Alluvial aquifers may be laterally restricted along erosional segments of fluvial (V-shaped) canyons incised in bedrock. The relationship between groundwater and streamflow levels in depositional segments of fluvial canyons may vary seasonally, with alluvial aquifers discharging to stream channels during the spring and streamflow discharging to alluvial aquifers during the summer. Excessive bed-loss in broad alluvial valleys generally results in diminished groundwater levels with increasing distance from the stream channel. The relationship between geomorphology and groundwater dictates the dynamics of the water regimes and thus the character of riverine-riparian communities.

Where alluvial soil deposition along valley floors out-paces the rate of fluvial erosion, alluvial-filled valleys form. Great Basin valleys are commonly filled to great sediment depths, and under the influence of soil texture and longitudinal profile they can result in depleted streamflows, as surface waters enter the soils and become alluvial. The Great Basin has had high lacustrine modification (by the large ancient inland seas like Bonneville and Lahonton) below 5,000 feet from ancient lakes. Today's hydrologic processes are slowly reworking these older valley types. Perennial streams through these areas often produce adjacent wetlands flanked by salt meadows.

V-shaped and notch-shaped canyons are primarily results of fluvial and colluvial processes. If colluvial processes dominate, V-shaped canyons form; if fluvial processes dominate, U-shaped or notched-shaped canyons form. U-shaped valleys however can also be formed by relict glacial processes. It is extremely important that this classification properly define the streamflow regimes, including summer base flow, winter fish survival flow, and effects of peak flows on valley forming processes. Peak flows usually correlate directly to climate, basin form, and stream network form, e.g., relief, time of concentration, magnitude of upstream drainage area, amount of vegetation cover on the watershed, and type of parent material.

Another important descriptor of the classification requires proper identification of confined and unconfined channels. Confined channels occur where mass failures, bedrock, or headcutting dominates channel form and unconfined channels occur where constriction by mass failure or other type of controls are absent. The importance of the channel's shape on the behavior of peak and low flow water column shape must be accounted for.

Biotic

Many floral and faunal interactions influence riverine-riparian ecosystems. As soils become more mesic greater productivity of riparian vegetation results. Vegetation modifies channel and streambank morphology. Streambars, permanently flooded channels, and erosional areas are the beginning and ending points from which succession, if there is such a thing in riparian development, starts and ends. Although there are many biotic interactions, usually the bottom line in any cumulative watershed or water quality assessment is the fisheries. This classification is built primarily to display fisheries resources, their condition, and the processes that determine and control this condition. Therefore, the biotic section is devoted mainly to how this process addresses fisheries needs.

Platts (1974) found that in the Idaho batholith the main salmonid fisheries resources were located in very few geomorphic and aquatic habitat types. Most landform types are incapable of sustaining a fishery. Thus, the land and water manager could concentrate his efforts on small definable areas of land in need of intensive management. Lanka and Hubert (1987) found that drainage basin morphology and trout standing crop were related. With geomorphic variables alone they could predict trout standing stock as accurately as they could with stream habitat variables or models. Platts (1979) demonstrated that streams reflected both the hydrology and biology of their watersheds, and that fish production could be explained by geomorphic processes in the drainage basin.

MOST LANDFORM TYPES ARE INCAPABLE OF SUSTAINING A FISHERY. THUS, THE LAND AND WATER MANAGER COULD CONCENTRATE HIS EFFORTS ON SMALL DEFINABLE AREAS OF LAND IN NEED OF INTENSIVE MANAGEMENT.

The ability to address fisheries resources by a watershed diagnostic and accumulative approach is a quantum leap beyond the present method of just conducting fisheries inventories. Existing inventories of a single resource cannot show how the fishery is integrated and interacts with its surroundings and other resource uses. A fishery is never isolated, and much of its success is influenced by adjoining areas from which it receives its energy and habitat quality.

The ability of fish to move within tributaries or from tributaries to mainstems and back for winter-summer rearing, migration, and to escape from lethal conditions, means several riverine-riparian complexes must be addressed to form the evaluation. Their habitat components are not only linked geographically to one another but hierarchically through the aggradation of lower level systems. These geographical connections in the hierarchical context define the state of their systems.

This classification approach is based on the premise that the number of riverine-riparian complexes is workable at the overall watershed level as well as the tributary level, and that fish populations are affected and controlled by the lands and vegetation around them, especially including the geology and hydrology of their drainage basin. The system becomes very powerful if similar fish populations can be expected to respond in a like manner to the stresses or benefits applied by similar management practices. A riverine-riparian classification system will increase our ability to predict and eliminate stress and to increase beneficial effects. Thus, fisheries input becomes not only highlighted but workable in the decision making process (general management level).

Classification can incorporate cumulate effects on the fisheries, outline species distribution, estimate smolt or young-of-the-year production, determine the effects of pollutants, pinpoint watershed areas where the largest return for the money would be gained in such things as changes in livestock management or stream repair projects, and identify the states of the system.

METHODS

Maps are produced that compile climatic, geologic, geomorphic, hydrologic and biotic characteristics. These types of maps or related maps, are already available at the higher levels of resolution (Bailey 1976, Fenneman 1946), at the mid levels of resolution (Wertz and Arnold 1972), and at lower levels (Platts et al. 1988). Lower level mapping found in Platts et al. (1988) is seldom available. Once mapping is done, inventory determines existing states of systems, and selected areas are sought to define natural states of systems. Criteria are set to identify and map riparian community types, soil types, streamflow regime types, landtypes, valley bottom phases, and riverine and aquatic types which are aggregated to identify riverine-riparian complexes. These complexes are described and the different states differentiated and displayed.

Mapping

Mapping and GIS (General Integration Systems) are used to identify and locate all components necessary to type the riverine-riparian complexes. Thus, those types that function similarly and differently are identified. The key to the mapping is that the land, water, or fishery managers can locate themselves and place themselves in the context of the complete watershed and its casual effects. Mapping is assembled at several levels of resolution, depending on how the information is to be used.

Existing mapping takes care of most hydrographic, geologic, and geomorphic classes at regional scales of resolution (1:500,000 to 1:3,000,000). Higher resolution mapping at a landscape scale (1:24,000 to 1:500,000) is also usually available. Typing scale maps (1:2,000 to 1:24,000) are usually not readily available and need to be acquired. Some agencies are building good libraries of the 1:2,000 scale which allows excellent interpretation.

Mapping done at different scales can be rectified by the excellent GIS computer software systems that are now available. This allows the necessary overlaying for interpretation. At the finite level, map units are generally ground truthed by step transects through delineations. Low level aerial maps have scale recording devices located on the maps at key intervals. Hydrographic regions are mapped at 1:1,000,000 scale, hydrographic basins at 1:500,000, sub-basins at 1:250,000, geomorphic units on 7.5 minute topographic maps or similar scale aerial photographs for location purposes, and color-infrared (CIR) at 1:1,200 to 1:2,400 to delineate water regimes and riparian community types. Through analysis of small-scale photos distinct patterns of homogeneity and differences can be identified and explained. The use of digital image processing may also help better identify riverine-riparian types and complexes. For mapping to be useful it must be integrated into a computer sensible format.

Although this process is being outlined and tested mainly for fisheries purposes, it has application to a range of users including wildlife biologists, hydrologists, and range conservationists. Accurate types of lands and waters that respond in predictable ways to an application of selected management practices is invaluable. Knowledge of the environmental and ecological components allows these users to input directly into the decision making process.

CLASSIFICATION FORMAT

Lotspeich and Platts (1982) outlined a method for land classification based on ecosystems using watersheds as the basic units of identification. The method is based on geo-climatic factors developing watersheds providing the physical basis for ecosystem development. The system makes use of coarse level resolution of regions (Bailey 1976, Omernik and Gallant 1986) which have little value in riverine-riparian evaluation except to identify regional differences. Their system then goes further to provide techniques to classify at low levels of resolution. This classification uses much of that developed by Lotspeich and Platts (1982).

This classification nestles land units, both natural and cultural, in a hierarchy of systems, each having its own surrounding environment (Tables V-1 and V-2). This links all elements of the land. The system classifies mainly according to physical and biotic causes but also enters effects to account for cultural control. The high elevational extremes of the Great Basin, 14,495 (4.418 meters) to 248 feet (75 meters) below sea level result in large differences between landscapes. Glacial, fluvial, alluvial, and lacustrine processes have all left their mark on the land.

Table V-1. Classification format.

I.	Domain	Subcontinental area of related climates.
II.	Division	A subset of Domain delineating single regional climates as defined by Trewartha and Horn (1980).
III.	Ecoregion	A subset of Division based on land surface form as defined by Fenneman (1931). A broad vegetation region with the same types of zonal soils. Climatic climax at the level of Kuchler's potential vegetation types. Four major criteria are landform, potential natural vegetation, land use, and soil.
IV.	Geologic District	A subset of Ecoregions delineating more homogeneous areas banding together uniform geologic landforms at the level of Hammond's land-surface form regions.
V.	Landtype Association	Groups of closely related types within a Geologic District with recurring patterns of landforms, soil, and vegetation.
VI.	Landtype	Group of neighboring phases within a Landtype Association with similar soil series or families with similar plant communities at the level of Daubenmire's (1968) habitat types.
VII.	Valley Bottom Type	Group of neighboring sites within Landtypes belonging to the same soil series with closely related habitat types.
VIII.	Riverine-Riparian Complexes	Repeating units within Valley Bottom Types that are made up of distinctive groups of riverine and riparian types.
IX.	Riverine & Riparian Types	Repeating types within Riverine and Riparian Complexes dictated by the location and combination of form, soils and water.
X.	Riverine Site	What's at the final point (i.e., pool, riffle).

Bailey (1976) and Omernik and Gallant (1986) rely on the influences of climate and physiography. Therefore, classifications were used from the Domain to District levels. Wertz and Arnold (1972) principles are used for the landtype association and landtype levels. We developed the lower levels of the classifica-

Table V-2. Lower level classification format from Valley Bottom Types to Site level for northern Nevada.

- I. Landtype Associations (Same soil series with closely related habitat types)
  - A.[a] Glaciated lands
    - 1.[b] Glacial basins
    - 2. Glacial valleys
      - a. Riverine-riparian complexes
  - B. Fluvial canyons
    - 1. V-shaped canyons
      - a. Riverine-riparian complexes
    - 2. U-shaped canyons
      - a. Riverine-riparian complexes
  - C. Alluvial valleys
    - 1. Unconfined streams
      - a. Riverine-riparian complexes
    - 2. Confined streams
      - a. Riverine-riparian complexes
  - D. Lacustrine basins
    - 1. Open
      - a. Riverine-riparian complexes
    - Closed
      - a. Riverine-riparian complexes

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[a] Landtypes

[b] Valley bottom class

tion to fit fisheries needs. We keep our classifications, unlike Bailey and Omernik and Gallant in a watershed perspective. The system is aggregated upwards until it covers complete basin watershed boundaries.

The testing that is now going on in northern Nevada covers diverse areas from flat to mountainous terrain. The system used in flat terrain produces riverine-riparian complexes that cover large land areas. In the mountainous terrain, because of land form roughness and diversity, this homogeneity is lost and riverine-riparian complexes become much smaller and more diverse.

The classification format is listed in Tables V-1 and V-2 from the domain to the site level. Each hierarchical level is addressed separately.

Domain

These delineated areas are subcontinental areas of related climates. This is the highest level, as proposed by Bailey (1976, 1978), and is based on a broad climatic separation of arid and humid regions. This level cuts across geologic elements and should be thought of as a broad band of transition (ecotone) between deserts and grasslands on the arid to semi-arid lands to humid forest lands. The Domain level is of little value in the interpretation of fisheries resources, but does identify areas with respect to precipitation.

Division

The Division contains a single regional climate at the level of Koppin's types as described by Trewartha and Horn (1980). This level is of little value in the interpretation of fisheries resources but does identify climate with respect to precipitation, temperature, and seasonality.

Ecoregion

A broad vegetation region having the same types of zonal soils. Details of vegetation and drainage patterns are visible as they relate to lithology and structure. Land forms at this level took millions of years to form, and may include a diversity of climatic patterns with resultant large vegetation patterns that may appear uniform but are really quite complex. Climatic climax is at the level of Kuchler's potential vegetation. This is the first level that affects a single, micro-climatic zone that starts to influence a land form in its entirety. Correspondence between macro-climate and land form patterns begins to emerge. Vegetation details are still not clearly visible. This level is of little use in the interpretation of fisheries resources.

Geologic District

Uniform land forms at the level of Hammond's land-surface form region are now evident. This level (the connecting bridge) can assist in land use planning efforts, but only on a very general scale. This level has little interpretive value for fisheries resources but it does show climax vegetation, as well as soil groups. At this level the first resultants from geo-climatic interaction express themselves.

Landtype Association

Groups of closely related geomorphic types with recurring patterns of land forms, lithology, soil and vegetation series are now identifiable. This is the first level where fisheries can be addressed with some information of value being attainable. This level is still too high, however, to provide much information. Association does imply there are interactions of various landscape elements now discernable. Individual lithologies, stream habitats, and mosaics of vegetation are now evident.

Landtype

Groups of neighboring land phases having similar soil series or families with similar plant communities at the level of Daubenmire's habitat types are now evident. Landtypes are mapped mainly on the principal geomorphic processes (e.g. erosion or deposition) influencing landforms. At this level cumulative effects can be aggregated upwards to cover cumulative impacts at the watershed level. This level is still difficult to work with because riverine-riparian complexes can be bordered on each side by different landtypes. Platts (1974) found that at the landtype level, a variation in fish populations could be identified and that they reacted to similar landtypes in similar ways.

Landtypes repeat themselves to form a mosaic, and because similar landtypes contain similar streams they allow information and understanding to be transported over large geographic areas. At this level, with information from the riverine-riparian complex level, specialists can effectively evaluate past, ongoing, and proposed land uses. For project and site level management, however, the riverine-riparian complex level is needed.

Valley Bottom Type

Groups of neighboring sites belonging to the same soil series contain closely related riparian and riverine aquatic habitat types. This level starts providing answers to fisheries questions as long as they are not too complex or detailed. Sometimes this is a better level than the landtype level to aggregate cumulative effects to the watershed level. Fish react to valley bottom classes at general levels of response (e.g., fish react differently to a glacial valley bottom class than to a lacustrine lower elevation valley bottom class). Riparian and riverine responses to casual effects are manifested. Streambank types and degree of channel incision or confinement are displayed.

Riverine-Riparian Complexes

The riverine ecosystem during base flows includes mainly non-vegetated wetland and deep water habitats that are contained within a channel or below top of banks (modified from Cowardin et al. 1979). The riverine-riparian ecosystem is made up of groups of riverine-riparian complexes. Usually a valley bottom class contains more than one riverine-riparian complex. This complex is formed by the union of riverine-riparian habitats and the uplands no longer confuse the analysis. At this level the frequency and level of flooding, low base flows and the character of alluvial groundwater can be discerned. Fish identify and live in these complexes, sometimes in a single complex. Non-vegetated channels and streambanks are identified. Riparian community types are distinguished by a distinctive assemblage of vegetation. The community types are now appearing on similar climatic, geologic, geomorphic, and hydrologic conditions. Therefore future conditions have high predictability.

Streambank and channel forming processes are evident, which work well for addressing the impacts of livestock grazing. Channel forming types (e.g. gravel bar, sandbar, undercut banks) are also useful for monitoring and identifying trends. Processes responsible for riverine qualities and condition can now be determined relative to the environmental gradients of (1) latitudinal gradient from north to south, (2) elevational gradients from headwaters to sinks, and (3) lateral gradients between valleys and uplands. Physiognomic classes and conditions are now mappable. The saturation of the ground surface, groundwater levels and their fluctuation as related to rooting depth of vegetation is now discernable.

Riparian Community Types

This concept identifies the *existing* riparian community types. The natural community type must usually be determined by other means in the Great Basin because of heavy vegetative modification by cultural uses, mainly livestock grazing. Nonpoint source impacts on riparian vegetation can clearly be defined at this level. The riparian ecosystem includes lands transitional between aquatic and upland habitats that are characterized by hydric soil and distinctive vegetation requiring free or unbound water (BLM 1986). Assuming continuity there is a single riverine-riparian ecosystem for a given watershed.

Riparian habitats are composed of one or more dominant riparian community types, and typed based on floristic similarities in both the overstory (if present) and the understory (Youngblood et al. 1985). This constitutes the most finite level of the vegetation component of the classification. The identification of types is based on the presence/absence and cover of a few indicator species that have high constancy. This reflects the integration of climatic, geologic, hydrologic, geomorphic, and soil conditions.

Riverine Community Types

The riverine ecosystem is composed of riverine complexes which are comprised of riverine community types. They are identified by parameters such as streamflow, channel and water column morphology, substrate, and bank characteristics. Riverine habitat types consist of glides, pools, riffles, pocket water, rapids or whatever characteristics the water column takes as influenced by its water column and adjacent channel and streambanks. These types are aggravated upwards into complexes to better cover fish life history requirements.

Site

This level is almost a point, it is an aspen clump, willow patch, pool, a riffle, a glide. This level is completely homogeneous.

STATES OF SYSTEMS

The watershed controls stream structure and function, thereby determining the character of the riverine-riparian complexes. Watershed and riverine-riparian complexes, in turn, can be described and quantified, thereby, determining their state. Describing and quantifying a riverine-riparian complex at a known state and identifying this with watershed condition allows identification of the states a system will occupy in relation to the casual effects that put it in this state. The state of a complex determines the integration of the conditions of its components, such a substrate, biota, streambanks and channel form. A state is linked to a surrounding system. The fisheries within the state are maintained not only by the complex and its immediate environment, but the watershed in which the complex is embedded. The complete range of states a complex can attain and maintain determines the habitats over which the manager has control.

Streams are difficult to understand when only the existing state is known. They must be placed in perspective as to where they have been and where they are going. Just knowing the present state doesn't provide much information with respect to the many states the stream can assume. Table V-3 conceptualizes the states that a system can attain. The natural state is usually the most productive state to maintain for fisheries purposes but may not always be the most cost effective. Stream repair work is usually a method to try and move a present state towards some unnatural condition. Stream enhancement means the attempt is to move the state beyond the natural capability to a desired potential, and hope to hold it there. The main reason stream repair and stream enhancement projects are not cost effective and why most of them fail to meet objectives, is because specialists are unable to define the states of the system and understand the processes needed to attain and maintain desired states.

A useful classification approach must account for the present state, the natural state, and those states the stream can occupy under cultural influences. As Table V-3 implies, even a stream occupying natural condition, can attain different states, because nature is by itself variable. Knowing the states of the system and what causes these states allows accountability for short- and long-term behavior. This in turn determines the capacity of the system to maintain productivity. Understanding states allows a conceptual view of how riverine-riparian complexes are organized in space and how they react over time. In our time frame, we need to classify and identify states over instantaneous time, and within 5-to 50-year horizons. To get beyond this or even try to grasp the geologic time span of the future answers very few questions facing us today. A reconstruction of past events, however, may often give us some insight on how a proposed course of action affects a given system.

Table V-3. Conceptual example of the states occupied by a riverine-riparian complex.

State	Class
Enhanced	1
	2
	3
Natural	4
	5
	6
	7
Cultural	8
	9
	10
	11
	12
	13

States define limiting and beneficial factors. Without this approach our knowledge of limiting factors is inhibited. Confining limiting and beneficial factors then become the regulation factors. These factors then determine species numbers, biomass and distribution in a manner that is as identifiable and classifiable as a fingerprint. The classification method then classifies the riverine-riparian print. Physical, chemical, and biological variables that cause these "fingerprints" vary between different ecoregions or different systems, thus giving us a method to track and identify them. Land uses change these tracking variables and set up different states of systems by intercepting natural environmental controls.

The classification system must not only identify the states but must display them. The approach given here uses quantitative descriptions in combination with photographs, computer simulation, or artists conceptions so that the land manager will have visual input into decision making. Thus, the land manager understands why the complex is in the existing state, what the natural state is, if different, and what states the complex can attain under different management scenarios. This information can be obtained by tracking performances of riverine-riparian complexes over time, but much more efficient is recording the same riverine-riparian complex in its different states over space and bringing this interpretation together by understanding the natural processes operating under a given set of environmental controls.

DISCUSSION

The classification proposed is a natural system based on ecological concepts, but able to accept and absorb cultural influences. By visualizing, with documentation, the condition of the riverine-riparian complex in the natural states, existing state, and cultural states we minimize the bias and frustration now facing managers. The system is developed from the broadest to smallest unit to provide all levels needed in land use management and monitoring. It is quickly acknowledged that the higher levels are essentially vague for managing riverine-riparian ecosystems and questions are mainly answered at the lower levels. However, the higher levels of the hierarchy, because they are ecological and set by causes of differences between classes, define the set of geo-climatic controls. That is, the big picture controls the smaller systems. The key to success of any classification system is how effectively and accurately it will answer questions. Classification systems should be tested by these questions and the answers produced to evaluate their accuracy.

The approach integrates the management of land and water resources to identify the compatibility of land and water uses with a fishery or a wildlife population. The approach recognizes the linkages between a riverine-riparian ecosystem and its complete watershed. The classification avoids an artificial separation of the terrestrial and riverine system because land and water function together as a unit. Although simple in approach, it addresses the complex variability of natural systems.

Existing fisheries inventories usually provide only a description of a single resource and therefore do not show how the fishery is integrated and interacts with other resource uses. A fishery cannot be managed by itself but must be managed on an integrated basis with respect to its surroundings as part of or as an independent ecosystem. The regional type classification framework puts any location into perspective as to how the fishery fits into its surroundings. Are water quality standards being met? Is the fishery a unique situation that needs immediate attention? Are there significant habitat deviations from the natural state? And just how well are the surrounding land use activities being managed?

Classification can lead to proper management of each watershed. Proper management of a watershed also means that its component states are being properly managed. If the components (i.e., riverine-riparian complex) are properly managed then nonpoint source pollution is under control, valley forming processes are ongoing and in synchronization with the stream and its valley, habitat condition and trend are being tracked, and the fish population is being properly managed.

CLASSIFICATION SECTION DEFINITIONS

Associations - Map units composed of two or more dominant taxa, which could be delineated separately at the scale of mapping that are expected to respond similarly to management applications and inclusions of contrasting taxa.

Bank-forming types - Occur on the floodplain and are flooded by overbank discharge; characterized by sediments dissimilar to that of the stream bottom (i.e., soil).

Basin - A watershed subset to a subregion or, for the Great Basin, watersheds draining to a particular sink; 1:250,000 to 1:500,000 scale.

Best Management Practice - A practice that supposedly will meet state and federal regulations and will not damage competing resource uses. A practice or usually a combination of practices, as a means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals as set up by federal or state standards to derive beneficial use of a stream.

Channel Confined - The water flow is completely confined within the channel; it does not flow onto a floodplain at high water. A channel without visible signs of a floodplain or one where artificial barriers prevent overflow.

Channel Forming Types - Occur within the confines of the stream channel and are flooded by moderate-to-high stream discharge; characterized by substrate similar to that of the stream bottom (e.g. sand and gravel).

Climate - The agent acting on geologic processes to produce a landform.

Community Types - Community types are concepts based on floristic similarities in both the overstory (if present) and the understory of riparian communities (Youngblood et al. 1985) and constitute the most finite level of classification in this approach. Community types are identified at the most discrete scale of mapping (< 1:2,000 scale). Community types may be aggregated into two types of map units:

(1) **Complexes** - Map units comprised of two or more dominant riverine and riparian taxa that occur in complex arrangements.

(2) **Consociations** - Map units composed of a single dominant taxon and inclusions of contrasting taxa.

Cultural Landscapes - Those in which the relationship between human communities and their nonhuman environment is the focus of inquiry (Hills 1976).

Ecological Land Classification - An ordering of land units based on climatic criteria (macro-climate and microclimate) that combines the elements of landforms, soils, and vegetation into one integrated unit. Until this is achieved, no land classification can be called natural (Daubenmire 1956).

Ecosystem - "A system resulting from the integration of all living and nonliving factors of the environment"—a definition by Tansley (1935, p. 12). An extension of this definition could imply that ecosystems are productivity systems in which environment comprises the total physical, chemical, and biological surroundings of an organism including habitat.

First Order Stream - "A stream with sufficient continuous flow to support an aquatic biota at all seasons" (Lotspeich 1980, p. 582). This definition is almost identical to that of Hynes (1972).

Floodplain - The alluvial surface adjacent to a channel that is frequently inundated.

Fork - A watershed subset to a tributary basin.

Geologic Units - Portions of watersheds that are of similar geologic structure and composition.

Geomorphic Units - Portions of geologic units that are of similar geomorphic structure and composition.

Herbaceous Community Type - Forbs, grasses, moss and lichen cover greater than 60 percent of the ground surface and herbaceous vegetation is dominant; woody vegetation covers less than 30 percent of the ground surface.

Hydrographic Unit - Watershed drained by a named stream or group of streams.

Intermittently Flooded - The surface is frequently flooded for brief intervals due to minor fluctuations in stream discharge; infrequent flooding may occur during any period of the growing season; commonly associated with streambars and features within the stream channel.

Land - All terrestrial material above sea level (including Death Valley in the Great Basin) and including all water, lakes, and streams flowing from or across these lands.

Landform - The physical shape of the land reflecting geologic structure and processes of geomorphology that have sculptured the structure (Hunt 1974).

Landscape - An aggregate of landforms, together with its biological communities.

Landtype - Identified based on the principal geomorphic process (i.e., erosion or deposition) characterizing landforms; 1:24,000 to 1:60,000 scale.

Landtype Association - Identified based on the principal geomorphic mechanism (e.g., glacial, fluvial, alluvial or lacustrine) apparent in landscapes; 1:60,000 to 1:125,000 scale.

Landtype Phase (Valley Bottom Type) - Identified based on differences in potential bank communities and soil types; 1:2,000 to 1:24,000 scale.

Macro Climate - The potential, effective climate just beyond the local level that modifies irregularities of landform to form a climatic continuum of solar derived energy that changes uniformly from equator to pole (Hills 1960). Koppen's (1931) world climate systems is an example of macro-climates.

Meso-Climate - The macro-climate modified by local irregularities of landforms, aspect, slope gradient, and elevation. The meso-climate creates a mosaic of plant communities. Meso-climate can be thought of as precipitation effectiveness in a local setting where incoming energy is constant but the effect of orientation and shape of landforms modifies the macro-climate.

Microclimate - The climate within the vegetation-soil complex as modified by shade, soil texture, and air movement. Although important when studying site energetics, the microclimate will not be considered during our classifying process.

Natural Attribute - A quality, characteristic, or property belonging to a person or thing. We confine the term to properties of natural landscapes that developed in the absence of human cultural influences. We stress the independent variables of geology and climate as the primary controls over dependent variables such as soil, vegetation, and water.

Natural Landscapes - Those in which the relationship between the biological communities and the physical environment is the focus of inquiry (Hills 1976).

Nonpoint Source - A diffuse form of water-quality degradation produced by erosion of land that causes sedimentation of streams, eutrophication from nutrients and pesticides used in agricultural and silvicultural practices, and acid rain resulting from burning fuels that contain sulfur. Even if all point sources of water pollution were to meet established standards, our waters still would not meet these standards if nonpoint sources were not controlled by the best management practices. Moreover, because nonpoint sources affect all watersheds, especially those of low-order streams (1-3), all waters of the nation are under federal jurisdiction with regard to water-quality protection.

Phase Modifiers - Identified based on criteria that are responsive to management applications and that are related to the values of both stream and riparian habitats; criteria may vary based on the landtype or the type of management considered; potential criteria for identification include the condition of streambanks, the extent of streambars, and the degree of channel incision or aggradation relative to the floodplain; < 1:2,000 scale.

Permanently Flooded - Water covers the surface throughout the growing season; the depth of water is less than that which restricts the establishment of wetland vegetation.

Physiography - The study of the three major physical divisions of the globe: land (geomorphology), atmosphere (meteorology and climatology), and oceans (oceanography) (Lobeck 1939).

Physiographic Province - A region of similar geologic structure and climate with relief that differs from that of adjacent regions (Fenneman 1931); 1:1,000,000 to 1:3,000,000 scale.

Physiographic Section - A subset of a physiographic province used to identify areas with a more discrete range in geologic structure and climate (Fenneman 1931); 1:500,000 to 1:1,000,000 scale.

Physiographic Subsection - A subset of a physiographic section used to identify areas with still more discrete range in geologic structure and climate (ibid); 1:250,000 to 1:500,000 scale.

Potential State Condition - A riverine-riparian state obtained by natural or artificial means. Nature can cause a state to exist or man can create a state through his activities. The condition of a defined system in terms of the factors that generate and control functioning of the system at a specific time. Similar to the concept of soil forming factors for soil or other geo-climatic interactions and processes.

Region - The watershed of the highest order streams draining to the ocean or, for the Great Basin Region, the watersheds lacking external drainage to the sea; 1:1,000,000 to 1:3,000,000 scale.

Relief - An index of the potential energy available in a drainage basin measured by the difference in elevation between specified points on a landscape.

Riparian Community - Areas characterized by a distinctive assemblage of obligate and/or facultative hydrophytic plant species and soils that are saturated by groundwater within the rooting depth of vegetation during some portion of the growing season.

Riparian Community Types (RCTS) - Concepts based on floristic similarities in both the overstory (if present) and the understory of riparian communities (Youngblood et al. 1985).

Riparian Ecosystem - Land transitional between aquatic (stream) and upland ecosystems that are characterized by hydric soil and distinctive vegetation requiring free or unbound water (Bureau of Land Management 1986).

Riverine Ecosystem - Land and water contained within the channel of a stream; includes streambars and the stream bottom; substrates are fluvial sediments with low degree of soil development.

Riverine-Riparian Habitat (RRH) - Any designated area within the riverine-riparian ecosystem (RRE) that is generally comprised of several contrasting stream and riparian types; the diversity within RRHs varies as a function of the scale of perspectives.

Riverine-Riparian Ecosystem (RRE) - The union of the riverine and riparian ecosystems; for a given watershed there is a single RRE, usually bordering the waterway.

Rock Type - Areas of similar surficial mineral composition that weather to form sediments of distinctive size-fractions and mineral composition under similar climate; 1:24,000 to 1:250,000 scale.

Saturated - The substrate is saturated to the surface for extended periods of the growing season but surface water is seldom present; commonly associated with springs and seeps.

Seasonally Flooded - The surface is flooded for extended periods during spring runoff of most years, but surfaces are dry by the end of most growing seasons; commonly associated with floodplains and channel levees.

Semi-Permanently Flooded - Water covers the surface throughout most of the growing season.

Sensitivity - Likelihood, extent, and rapidity with which a given stream or complex will change in response to an applied stress or benefit.

State - A description of conditions of an ecosystem at a given place and time.

Streambank - The interface between riverine and riparian ecosystems; limits the lateral extent of streamflow during periods of moderate to high streamflow.

Stream-Bar - Occurs within the stream channel; vegetation covers less than 60 percent of the ground surface; subclasses are named based on the particle-size distribution of the mineral substrate (e.g., cobble bar, gravel bar, sand bar, silt bar).

Subbasin - A watershed subset to a basin; 1:100,000 to 1:250,000 scale.

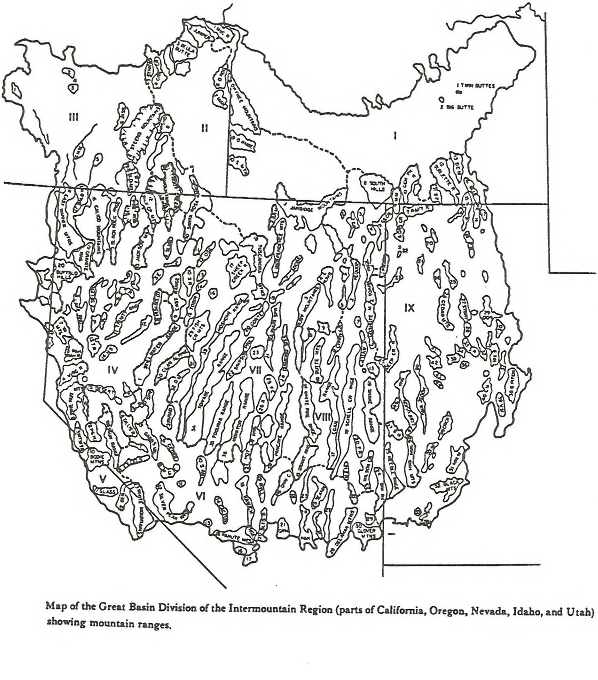
Sub-Irrigated - The surface is seldom flooded but groundwater level is within the rooting depth of vegetation for some period of the growing season; commonly associated with the toes of alluvial landforms encroaching from uplands and with stream terraces elevated above the floodplain as a result of channel degradation (down-cutting).

Subregion - The watershed of major streams draining regions or, for the Great Basin, the amalgam of watersheds of similar hydrographic character; 1:500,000 to 1:1,000,000 scale.

Tributary Basin - A watershed subset to a subbasin; 1:24,000 to 1:100,000 scale.

Water Regime - Areas distinguished by the frequency and duration of flooding, the dynamics of alluvial groundwater, and/or saturation by spring discharge.

Watershed - A drainage basin that gathers water from precipitation and delivers it to a larger watershed. Watershed is demensionless and depends on the area you need in the analysis. It could be a first order stream or all the basins composing a 6th order stream.


I
II
III
IV
V
VI
VII
VIII
IX
1 TWIN BUTTES
2 BIG BUTTE
8 SOUTH HILLS
JARBIDGE MOUNTAINS
OWYHEE MOUNTAINS
20 BUFFALO HILLS
10 BODIE MTNS
17 GLASS
30 CLOVER MTNS
TOIYABE
TOQUIMA RANGE
MONITOR RANGE
SCHELL CR RNGE
SNAKE RANGE
PAHUTE MESA

Map of the Great Basin Division of the Intermountain Region (parts of California, Oregon, Nevada, Idaho, and Utah) showing mountain ranges.

INVENTORY AND MONITORING

INTRODUCTION

The main purpose of this document was to put everything needed for evaluating livestock grazing impacts on riverine-riparian systems under one cover. Most of this was accomplished but, on occasion the user will have to refer to three other publications for more detail:

> **Armour C. L. et al. 1983.** Field methods and statistical analysis for monitoring small salmonid streams. FWS/OBS-83/33. Washington D. C. Fish and Wildlife Service.
>
> **Platts W. S. et al. 1983.** Methods for evaluating stream, riparian and biotic conditions. United States Forest Service, Intermountain Research Station, General Technical Report INT-138, Ogden, Utah.
>
> **Platts W. S. et al. 1987.** Methods for evaluating riparian habitats with application to management. United States Forest Service, Intermountain Research Station, General Technical Report INT-221, Ogden, Utah.

These reports should be in your library for quick reference. Study design and needed statistical design are covered in the Armour publication.

MONITORING STREAMBANK STABILITY INDICATORS

Dams, channel modifications, grazing, and logging are types of land uses that have the potential to accelerate instability in streambanks. Instability occurs when these activities change the hydrologic environment of the watershed and disrupt the balance of the streambank erosional and depositional processes. It is useful to identify key processes and monitor them and the rate of streambank erosion in order to evaluate management practices and anticipate changes.

Monitoring streambanks can take one of three approaches: (1) monitoring streambank change over time; (2) predicting the streambank change using predictive models; or (3) comparing the existing streambank habitat type with its counterpart in a near natural condition. All three approaches are discussed.

Streamside Cover

Rating streamside cover can be useful for evaluating effects of activities such as channelization, logging, or cattle grazing. However, this rating provides only a general evaluation of streamside cover. This measurement can be used to evaluate major vegetation type conversions or to classify aquatic habitats.

Table VI-1. Streamside Cover Rating

Rating	Description
5	Shrubs are the dominant streamside vegetation.
4	Tree forms are the dominant streamside vegetation.
3	Grass forms are the dominant streamside vegetation.
2	Forbs are the dominant streamside vegetation.
1	Over 50 percent of the streambank transect line intercept has no vegetation and the dominant bank material is made up of such materials as soil, rock, bridge materials, road materials, culverts, and mine tailings.

Rate only the exposed stream bottom, bank, and top of bank which is intercepted by the transect line. Higher level offsite vegetation is accounted for by the canopy closure, vegetation density, solar integrator, and shade methods.

The cover rating analysis in Platts et al. (1987) had tight confidence intervals about the mean (±4.1 percent). This was caused mainly because dominant cover tends to be uniform and so observers can rate conditions consistently, though not always correctly. Year-to-year precision and accuracy were poor, indicating special emphasis must be placed on accuracy when using this measurement.

Streambank Armoring

The streambank protection provided by vegetation and other materials against erosion from flowing water and ice is rated using

Table VI-2. Although stabilization by vegetation cover is the primary target of this rating, protective cover from bedrock, boulder, or rubble is also considered. Rate only the area of the bank or floodplain intercepted by the transect line within 5 ft. of the stream or to the top of the bank, whichever is the larger. Surprisingly, the confidence intervals around the means tested in Platts et al. (1987) were quite tight (about ±3 percent). However, year-to-year precision and accuracy rated only fair, implying observer error over time.

Table VI-2. Streambank stability rating

Stability (%)	Description
75 to 100	Over 75 percent of the streambank surface is covered by vegetation in vigorous condition or by boulders and rubble. If the streambank is not covered by vegetation, it is protected by materials that inhibit bank erosion.
50 to 74	Between 50 and 74 percent of the streambank surface is covered by vegetation or by gravel or larger material. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
25 to 49	Between 25 and 49 percent of the streambank surface is covered by vegetation or by gravel or larger material. The area not covered by vegetation is covered by materials that give limited protection.
0 to 24	Less than 25 percent of the streambank surface is covered by vegetation or by gravel or larger material. That area not covered by vegetation provides little or no control over erosion and the banks usually erode each year from high water flows.

Streambank Alteration

Certain land uses, such as road construction, logging, and livestock grazing, can destabilize the streambank and initiate channel modification. The streambank alteration rating may provide an early warning of changes that could eventually affect fish populations.

The streambank alteration rating reflects the changes taking place in the bank from any force. The rating is separated into five classes (Table VI-3). Each class, except the one with no alteration, has an evaluation spread of 25 percentage points. Once the class is determined, the observer must decide the actual percentage of instability. Streambanks are evaluated on the basis of how far they have moved away from native conditions. Therefore, the observer must be able to visualize the streambank as it would appear under conditions found in reference habitat type areas. This visualization makes the rating subjective, and dependent on the ability to train all observers to visualize the same optimum bank condition. Trampling by people or livestock and disturbance by bulldozers or trucks are examples of non-native forces that can alter streambank soils and form.

Table VI-3. Streambank alteration rating

Rating (%)	Description
0	Streambanks are stable and are not being altered by water flows, animals, or other factors.
1 to 25	Streambanks are stable but are being lightly altered excessively along the transect line. Less than 25 percent of the streambank is receiving any kind of stress, and if stress is being received, it is light. Less than 25 percent of the streambank is false[1], broken down, or eroding.
26 to 50	Streambanks are receiving only moderate alteration along the transect line. At least 50 percent of the streambank is in a natural stable condition. Less than 50 percent of the streambank is false, broken down, or eroding. False banks are rated as altered. Alteration is rated as natural, artificial, or a combination of the two.
51 to 75	Streambanks have received major alteration along the transect line. Less than 50 percent of the streambank is false, broken down, or eroding. A false bank that may have gained some stability and cover is still rated as altered. Alteration is rated as natural, artificial, or a combination of the two.
76 to 100	Streambanks intercepted by the transect line are severely altered. Less than 25 percent of the streambank is in a stable condition. Over 75 percent of the streambank is false, broken down, or eroding. A previously damaged bank, now classified as a false bank, that has gained some stability and cover is still rated as altered. Alteration is rated as natural, artificial, or a combination of the two.

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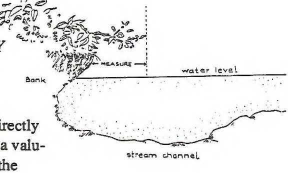
[1] False banks are those banks that have been cut back by some artificial force and are no longer immediately adjacent to the stream. They can become stabilized by vegetation, but base flows are usually too far removed from the stream to provide fish cover.

Because the 95 percent confidence interval around the mean and observer variation are quite wide (±12.3 percent), data interpretation requires care. Between the test streams studied in Platts et al.

(1987), there was a wide spread in the precision and accuracy of measurements. Overall precision was rated fair to good, but accuracy was rated mainly poor to fair. Therefore, caution should be used in evaluating the data from this measurement.



MONITORING CHANGES IN BANK MORPHOLOGY

Vegetative Overhang

Vegetation overhang indirectly provides fish food, and directly provides cover and shade over the water. "Overhang" is a valuable variable to evaluate land use effects that could alter the riparian habitat, such as livestock grazing, logging, and road construction. It measures, to the nearest 0.1 foot, the vegetation (excluding tree trunks or downed logs) within 1.0 vertical foot of the water surface. That part of the canopy higher than 1.0 foot will be monitored through the canopy closure, density, and solar integrator methods. The vegetation overhang is measured along a transect line, beginning at the farthest protrusion of the streambank over the water surface, to the farthest point that vegetation covers the water column. This measurement does not include the undercut. Therefore, bank undercut and vegetation overhang combined, give the total immediate overhead cover.

In Platts et al. (1987), testing showed that the 95 percent confidence intervals around the overhang means (±15.7 percent) was fairly wide, but year-to-year precision and accuracy rates were fair.

Streambank Undercut

Streambank undercut provides cover for fish and provides a condition favorable to producing high fish biomass, especially in small streams. Undercut is a good indicator of how successfully streambanks are protected from alternative land uses such as livestock grazing and road building. The undercut, if it exists, is measured with a measuring rod to the nearest 0.1 ft. directly under the transect line from the farthest point of protrusion of the bank to the farthest undercut of the bank (see fig. 34 in Platts et al. 1987). Water level does not influence this reading. If more than one undercut occurs under the transect, only the dominant (usually the larger) undercut is recorded.

Ninety five percent confidence intervals around the means (±18.5 percent) were found to be wide (Platts et al. 1987). However, year-to-year precision and accuracy are good. The major cause of the wide confidence interval is that the two points that define the undercut measurements are difficult to accurately determine. Also, a naturally high variation exists in size of undercuts.

Streambank and Channel Aggradation, Degradation and Shape

The rate of local streambank movement and changes in bank shape can be determined using the modified sag tape procedure developed by Ray and Megahan (1978) to profile channel cross-sections. The cross-sections should be plotted using the same horizontal and vertical scales to avoid exaggeration of bank-bottom features. Scales can be changed if banks need more detail for better analysis. Techniques to determine both bank and channel form and movement are provided here, but the streambank can be measured separately if so desired. For a complete description and figures demonstrating techniques see Platts et al. (1983).

The left bank is on the left side facing downstream. The cross-section profile readings always begin at the left transect reference marker (preferably a metal stake driven into the ground) and end at the right stake. This allows the computer to plot the left bank on the left side of the resulting graph. If streambank or cross-section profiles are going to be recorded over a number of years, then the location and elevation of the metal stakes must be surveyed and mapped relative to a permanent benchmark such as a large tree or bedrock knob. A surveyor's monument is a good benchmark if located away from the stream's influence. Surveyors can also collect data for a longitudinal profile at the same time. Disturbance from frost-heaving usually can be reduced by driving the stakes at least 3 ft. into the ground. Any movement of the stakes reduces the value of the cross-section for accurately monitoring streambank movements.

The sag-tape formula corrects vertical distances for the dip in the tape stretched across a cross-section based on tape weight and tension. Tension is measured with a spring scale mounted between one end of the tape and one metal stake. Very detailed instructions are available in Platts et al. (1987). Windy weather can affect both the tape sag and tension. The sag is also affected by the difference in elevation of the two end stakes--this is not the stake height above the ground surface, but actual elevations relative to a benchmark, and must be determined by survey. The vertical distances from channel bottom to tape are obtained by reading the tape level against a staff.

Some key features to map in are:

1. Ends of tape
2. Undercuts
3. Bank heights
4. Thalwag
5. Breaks in slope of banks or channel bottom
6. Edge of water, if accompanied by velocity measurements to model flow discharge.

Stream Channel-Bank Angle

Fish often congregate near the streambank for the cover it provides. If the bank has been cut away and laid or moved back from the water column, valuable rearing habitat has been lost. Measuring the channel-bank angle is effective for monitoring land uses that can change the morphology and relative location of the streambank.

A clinometer is used to measure the angle formed by the downward sloping streambank as it meets the more horizontal stream bottom. When the streambank is undercut, the angle is always less than 90 degrees. The angle is determined directly from the clinometer placed on the top of the rod as it forms the angle determined by the protruding edge of the bank to the midpoint of the undercut under the transect line (see fig. 36 in Platts et al. 1987).

When the bank is not undercut, the angle is greater than 90°. This angle is measured from the bank side by placing the clinometer on the top of the measuring rod aligned parallel to the streambank along the transect (see fig. 37 in Platts et al. 1987). The clinometer reading is subtracted from 180° to obtain the bank angle.

A streambank angle greater than 90° is easily read with precision and accuracy. An angle less than 90° is more difficult to read because multiple undercuts make it difficult to determine the points delineating the angle. The key is to include the midpoint of the dominant undercut in the bank profile. The 95 percent confidence intervals around the means are quite narrow (±4.4 percent), and year-to-year precision and accuracy are good (Platts et al. 1987).

Gully Processes

Gully forming and bank failure processes are not well understood. Methodology to predict whether a stream is going to headcut and form a gully has not been developed and would probably require a grid of channel profile cross-sections with accurate elevations. Pre-gullying indicators include piping, slumping, sliding or sloughing at neckpoints, but these processes can be present along channels that may never gully. When gullying can be identified, additional monitoring effort may be applied to these areas.

Early signs of bank failure, whether it be pre- or post-gullying are the predominance of cracks at the soil surface that indicate tensile stresses. Massive bank slumping is usually preceded by small scale undercutting at the base of the bank. The balance between rates of sediment supply and removal from the bank toe controls the bank profile and rate of retreat. This undercutting plus upstream-moving scarps can be picked up in the cross-section profiling and bank angle measurements.

MONITORING STREAMBANK CHANGES ASSOCIATED WITH TIMING OF FLOW

Stream Shore Water Depth

The stream shore water depth is critical for fish, especially young-of-the-year. It is also useful for evaluating riparian use that could modify the streambank and its riparian vegetation. The water depth at the stream shore is measured at the shoreline or at the edge of a bank overhanging the shoreline (see fig. 34, angle A1 in Platts et al. 1987). If the angle formed by the bank as it meets the stream bottom is over 90°, the stream shore water depth reading is always zero. If the angle is 90° or less, the water column goes under the streambank and the measurement of the stream shore water depth is greater than zero. The measurements for both shores can be totaled and averaged for an overall rating for the transect or kept separate to track each bank condition individually.

Because of the variation in stream shore depth, the test sample (Platts et al. 1987) had a 95 percent confidence interval about the mean of ±16.6 percent. These intervals were fairly wide, underlining the high variability and difficulty in standardizing the measurments. However, the precision and accuracy from this technique were good from year to year.

Water Column

The water column is the medium of support and movement for fish and other aquatic organisms and is strongly controlled by its bordering riparian vegetation. This vegetation reduces water velocity, which in turn reduces the erosion of banks and channels by increasing column and channel roughness. The amount of sunlight, which is the energy base for photosynthesis and stream temperature, is also controlled by the surrounding vegetation.

Vegetative Density Closure and Density

The concave spherical densiometer, model B (Lemmon 1956a and b) can be used on permanent points or transects to estimate relative canopy closure or canopy density caused by vegetation. Vegetative canopy closure is the area of the sky over the selected site (stream channel) bracketed by vegetation. Canopy closure can be constant throughout the season if fast-growing vegetation is not dominant, but density can change drastically if canopy vegetation is deciduous.

The concave mirror surface of the densiometer has 37 grid intersections forming 24 squares. At a probability level of 95 percent, tests show that average measurements of the same overstory area can be within ±2.4 percent of the mean (Lemmon 1956a and b). Because the instrument has a concave reflecting surface resulting in a field that includes lateral as well as overhead positions, an overlap of side readings occurs when readings are taken from the same point. To account for this bias, the modifications developed by Strichler (1959) are used and modified to better measure canopy closure and density. Strichler uses only 17 of the line intersects as recording points by taping a right angle on the mirror surface. Closure and density can be recorded on any selected site. Because the canopy over the stream is so important, the stream is used as an example of the densiometer's use.

For Stream Orders 1 through 4 -

The densiometer is held in the hand on the transect line perpendicular to the right stream bank 12 inches from and 12 inches above the shoreline. A tripod can be used for more accurate measurements. The arm from the hand to the elbow is horizontal to the water surface. Reasons for this position are: (1) it is easier to read the densiometer than if it were held directly on the bank; (2) the point of measurement can be repeated; (3) the cone of overhead observation is more directly overhead and takes in only a small area beyond the bank; (4) low overhead canopy overhanging the water column within 12 inches of the water surface has significant fishery cover benefits; and (5) the identical measurement settings eliminate parallax bias.

The densiometer is held away from the observer with the bottom of the V pointed toward the recorder. The observer's head reflection should almost touch the top of the grid line. Room is left to observe all points at 12 o'clock position at the top grid line. The densiometer must be kept level using the level bubble. The grid between the V formed by the tape encloses 17 points. The number of points (line grid intersects) that are surrounded by vegetation (canopy closure) or are intersected by vegetation (canopy density) are counted within the V-outlined area (maximum of 17). Each horizontal-vertical line intersect (point) has a value of 1.5 percent when four different recordings are made on streams of order 4 or less. On stream order 5 and larger where eight recordings are required each point has a value of 0.75 percent.

The same procedure used previously on the right bank is used on the transect line in the center of the stream. One recording is taken facing upstream and the other facing downstream. The Densiometer is held level over the transect line 12 inches above the water surface. The last reading is taken at the left shoreline. Readings are taken that simulate each of the four cardinal directions.

The points counted for each reading are totaled and multiplied by 1.5 to obtain the percentage canopy closure or canopy density, whichever is desired. The average of all closures or density measurements on all transects on the stream reach being studied are totaled and averaged to obtain the overall closure or density measurement. Then 1 percent is deducted from the scores between 30 and 65 percent, and 2 percent for those scores over 66 percent. No deduction is made for scores between 0 and 29 percent.

For Stream Orders 5 through 7 -

The same procedure is used as in stream order 1 through 4 except that eight recordings are made on these wider streams. This is required so that two stream shore readings do not over-influence the midchannel readings. The streambank readings are done the same as for stream orders 1 through 4. Two readings are taken at each quarter, half and three quarter intervals across the transect. One reading is taken facing upstream and the second one downstream, identical to the readings explained previously for the midpoint of the transect. The eight recordings are totaled and multiplied by 0.75 to obtain percentage closure or density. Then 1 percent is deducted from scores 30 and 65 percent and 2 for those scores over 66 percent. No deduction is made for scores between 0 and 29 percent.

Solar Heat Inputs

Using The Solar Pathfinder

Direct solar radiation, reflected radiation from the channel and water, atmospheric temperature, and riparian reflection are the major sources of heat absorbed by water. Of these the most important to streams, and the one most under our control, is the proportion of solar radiation intercepted by vegetation as modified by local topographic features.

Evaluating the effects of stream surface shading by vegetation or topographic features requires tracking the shadows cast throughout the solar energy receiving period. Only shadows that intercept the water surface are of immediate interest. The procedure used must account for the obstacle intercepting the sunlight and the length of the shadow this obstacle casts over the water. A simple approach is to use "The Solar Pathfinder™- The Energy Evaluator," a manual from Solar Pathways, Inc., 7800 Highway 82, P.O. Box 914, Glenwood Springs, CO.

The Solar Pathfinder takes a theoretical approach to integrating all of the effects of azimuth topographic altitude, height of vegetation, sunrise/sunset angle, latitude, time of year and hour angle, to determine the influences of solar radiation. The Solar Pathfinder allows all the vegetation and topography contributing shade to be permanently recorded at any time and displayed immediately. One recording documents the solar radiation input into the stream over the entire year, by month, half hour intervals, or any time frame of interest. A record of all obstacles providing shade is obtained and can be compared with future readings to evaluate changes over time.

The Solar Pathfinder consists of a transparent dome that reflects a clear panoramic view of the area around the site. This allows the shading objects to be identified and mapped. A built-in compass and bubble level permit orientation of the instrument. A pivoting base on a tripod allows the instrument to be used at heights that best fit the user. Work sheets are provided to facilitate a quick estimate of the absolute energy available to enter the stream surface using known radiation values. Monthly sunrise and sunset times, sunrise and sunset direction, interim shading patterns, and the energy-loss consequences of each shadow cast can then be determined.

The image of surrounding obstacles is viewed by looking directly down into the dome of the instrument (See fig. 24 in Platts et al. 1987). The sun need not be shining to use the instrument. If the sun is shining the operator may stand at any position around the dome, thus using his or her shadow to cover the dome so as not to stare at the sun's reflected image on the dome surface. Staring at the sun's image can be harmful to the eyes and should be avoided. If the observer's shadow falls across the area to be measured, this area can be profiled by changing the observer's position and if needed, shading the sun spot area with the hand. Only that area of the dome in the site panorama that coincides with the measurement area on the Sunpath Diagram™ is needed for analysis.

Diagrams

The Solar Pathfinder diagrams (pictured in Platts et al. 1987) have been prepared to correspond to the latitude requirements of the selected study areas. Therefore, the proper diagram must be used.

A monthly Horizontal Sunpath Diagram is inserted on the operating face. The instrument must be referenced to true south, in contrast to magnetic south. This is accomplished using a built-in declination adjustment. This setting is subject to accidental change and should be checked frequently. The adjustment (declination) between true and magnetic south can be determined using figure 25 in Platts et al. 1987. The Solar Pathfinder has a bubble level within the base support. Once level, the south-seeking compass needle is pointed directly at the south reference point.

The Sunpath Diagram allows the recorder to plot the solar interceptor profile that is used to obtain percentage solar availability for an average day, hour, or half-hour during any given month. Viewing from between 12 and 18 inches above the dome, and within 10 to 15 degrees of the vertical centerline, provides acceptable accuracy. Shading obstacles are mapped through coincident sighting of the reflected image from the outer surface of the dome with the image on the diagram card. Clouds are not considered an obstruction.

The monthly Horizontal Sunpath Diagram contains a sunpath arc for each of the 12 months and a solar time grid. To change solar time to standard time, two corrections are needed, one for time of year, and one for minutes of time from the Standard Meridian for a given time zone (See fig. 26 in Platts et al. 1987). For example in San Francisco in November, solar time from the Pathfinder is 3:20 p.m. and the monthly correction (from the right hand edge of fig. 26) is -14 minutes, while the longitudinal correction (from map portion of the same figure) is +10 minutes. Therefore Pacific standard time is really 3:16 p.m., a difference of 4 minutes. One hour is subtracted to convert to daylight savings time.

Data Collection and Calculation

The boundary between the unobstructed sky and all intercepting objects that appear on the horizon is traced with white grease pencil on the diagram. To avoid breaking the white lead, a light tracing is made under the dome and darkened later after removing the diagram from the dome.

The average percentage of monthly total radiation that will fall on the selected area is taken directly from the diagram (the small white numbers on the monthly curves). The solar radiation received at the site is estimated by adding the unshaded (unobstructed sky) half-hour numbers across the arc of the selected month or group of months or by subtracting these shaded numbers from 100 percent (See fig. 27 in Platts et al. 1987).

In the example in figure 27, during the month of July the numbers of the obstructed, or "under horizon" portion, are equal to 8. One hundred minus 8 means 92 percent of the potential solar radiation was reaching the site if canopy density was 100 percent. Using table 15 for Boise, Idaho, in July, the average British thermal units (Btu's) of heat per square per day available to the water (a horizontal surface) is 2,611. Then 2,611 x 92% = 2,402 so 2,402 Btu's are available to each square foot of surface water on the average each day in July. The Btu conversion table takes into account relative humidity and sunshine-cloud ratio. These tables are available for areas throughout the United States.

Interpretation

Streams, because of turbulence, usually experience mixing of waters from top to bottom. Thus, water temperatures are considered uniform throughout any given cross-section at any given instance for most streams. But canopy density can change with the seasons (due to leaf drop), canopy closure can change with land-use activities (such as logging and grazing), and the average afternoon air temperature is greater than the daily air temperature. Such potential modifying factors must be taken into consideration in the interpretation of the data collected. In addition, different streams are susceptible to different limiting factors at different times. Some streams may lose fish biomass because they are too cold in the winter (anchor ice and ice flows), while other streams may lose fish biomass because they heat too much during the critical parts of summer. Therefore, timing can play an important role. The Solar Pathfinder allows you to stratify or select those specific periods in which the data are needed to make a temporal or instantaneous analysis of the effects of solar radiation or even an estimate of the riparian canopy available to produce organic energy (such as leaf fall) to the stream.

Topographic shade dominates the amount of shade a stream receives because it determines the time of sunrise and sunset with respect to the stream surface. We usually have little control over topographic features. The riparian vegetation is usually the most important shading feature between sunrise and sunset that we have some control over.

Evaluating Critical Periods

To evaluate the effect of riparian vegetation on intercepting solar or reflected radiation during critical periods, the sun's path must be determined. The path must then be related to the interception of the sun's rays by surrounding riparian vegetation to determine effects of any proposed use or treatment. For instance, if logging were proposed in a riparian area, the location and amount of solar energy-intercepting vegetation proposed for removal needs to be determined so that changes in the amount of solar radiation reaching the stream can be evaluated to determine tradeoffs on a before-the-fact basis. This means that the topographic-vegetative boundary image drawn on the Solar Pathfinder diagram must be refined to include the typing of the solar energy interceptor (obstacle). Thus, the types and the effectiveness of the solar blocking obstacle can be identified.

The topographic-vegetative profile is further stratified into its solar interceptor types, and each interceptor type rated as to its ability to intercept all of the solar rays. Topographic features (streambanks, mountains and so forth) usually have a density of 100 percent with respect to sunlight penetration. The riparian vegetative density is obtained from canopy density measurements described previously.

As an example for the January sunpath arc, in which back-reflected radiation may be more important than direct solar radiation, the direct average solar radiation reaching the stream surface is (2 + 4 + 5 + 6 + 7 + 8 + 8 + 9 + [8 x 0.1] + [8 x 0.1] +[7 x 0.1] + 6) = 78.3 percent. At Boise, Idaho in January, there are 485 Btu's being received per square foot per average day. So each square foot at the site would receive an average of 380 Btu's per square foot per day. A more detailed analysis would be needed to determine whether the incoming radiation under a canopy of this type is more important in the winter than the back-reflection of heat, especially during nighttime conditions or under a much denser canopy where the stream surface would only be receiving 10 percent of the available solar energy.

In July the direct average solar radiation reaching the stream would be 93.2 percent. If this stream were susceptible to temperature problems, little relief would be obtained from existing riparian vegetation. Measures may therefore need to be implemented to increase the amount and height of the streamside vegetation.

TableVI-4. The Sun's Altitude and azimuth at selected northern latitudes on August 1.

Local Standard Time	Altitude Angle ( )	Azimuth Angle ( )
	35 N. Latitude	
0800	34.5	-88.6
0900	46.7	-78.9
1000	58.4	-65.2
1100	68.4	-42.0
1200	73.0	0.0
1300	68.4	42.0
1400	58.4	65.2
1500	46.7	68.9
1600	34.5	88.6
1700	22.3	83.1
	40 N. Latitude	
0800	34.3	-85.2
0900	45.5	-73.8
1000	56.1	-58.4
1100	64.5	-34.8
1200	68.0	0.0
1300	64.5	34.8
1400	56.1	58.4
1500	45.5	73.8
1600	34.3	85.2
1700	22.8	85.1
	45 N. Latitude	
0800	33.7	-81.9
0900	44.0	-69.1
1000	53.2	-52.6
1100	60.2	-29.7
1200	63.0	0.0
1300	60.2	29.7
1400	53.2	52.6
1500	44.0	69.1
1600	33.7	81.9
1700	23.1	87.0

(Cont'd)

Local Standard Time	Altitude Angle ( )	Azimuth Angle ( )
50 N. Latitude		
0800	32.8	-78.6
0900	42.0	-64.8
1000	50.0	-47.7
1100	55.8	-26.0
1200	58.0	0.0
1300	55.8	26.0
1400	50.0	47.7
1500	42.0	64.8
1600	32.8	78.6
1700	23.3	89.4
55 N. Latitude		
0800	31.7	-75.5
0900	39.7	-60.9
1000	46.5	-43.7
1100	51.3	-23.2
1200	53.0	0.0
1300	51.3	23.2
1400	46.5	43.7
1500	39.7	60.9
1600	31.7	75.5
1700	23.2	88.5

A more refined analysis of the vegetation can be made in certain situations, such as logging. This will allow a better determination of which trees or group of trees are being eliminated from the riparian habitat and what effects on solar radiation that removal might have. Furthermore the user may want to identify the gaps in riparian vegetation along the selected sun arc to determine what method would best fill the gaps. While this may be done directly from the diagram cards, it may help the evaluation considerably to also evaluate these gaps directly in the field. This can be done by using a clinometer in conjunction with the Solar Pathfinder angle estimator diagram. This grid gives a direct reading for azimuth (degrees east or west of true south) and altitude, or the elevation above the point on the horizon you are considering. The radial lines measure azimuth and the centric lines measure altitude. Both are recorded in degrees.

Because each hour of the time passes through 15 degrees of azimuth, it is easy to write the time of day (solar time) directly on the diagram. For example, 0 degrees or straight south would be 12:00 noon. At 15 degrees west it would be 11:00 a.m. and so on. The same approach is used to record the time by azimuth as the sun moves west at 12:00 noon. Thus, for any given time, the horizontal direction of the sun is quickly determined from the Solar Pathfinder angle diagram.

The true position of the sun at any given time can be determined by merely plugging in the altitude of the sun for any selected day, at any selected latitude, for any given time from tables found in meteorological books in local libraries. A fairly accurate approximation can quickly be obtained (for the monthly average only) by overlaying a reversed negative (so the black portion of the diagram becomes transparent and you can see through it) of the Pathfinder Sunpath Diagram.

Using the first method of getting the altitude from the tables, the user only has to line up the clinometer with the correct azimuth angle and shoot the correct altitude angle (see table 16 in Platts et al. 1987). That point selected by the clinometer is where the sun would be on that certain time and day. This allows the user to plot the path of the sun during the critical period. For instance the pathway could be visually plotted on August 1 between the hours of 10:00 a.m. and 2:00 p.m. when 48 percent of the total daily radiation would be hitting the surface of the water.

WATER QUALITY

Monitoring water quality measures the effectiveness of grazing BMP's in one of two ways. Monitoring is either a part of a comprehensive program or it is an end in itself without reference to other monitoring programs. In the first instance, we dedicate resources to monitoring biological or physical conditions most affected by the success or failure of grazing BMP's. Water quality may not be a critical issue. In the second case, however, water quality may be the central issue because it is anticipated that the land disturbance activity will have fewer consequences for biological or physical resources.

Because grazing BMP's protect large land areas, it is inappropriate to designate a few chemical, biological, or physical components as critical and ignore the rest. We assign the resources available to monitor the environment to what we think are the sensitive components. Usually, there are many components to monitor. As shown in Figure VI-1, water quality may be just one of the components so it cannot demand a disproportionate share of the monitoring resources.

The goals in this section are to (1) focus on those water quality constituents commonly affected by grazing impacts, (2) show that water quality monitoring can be an "early warning" system for grazing BMP's, and (3) integrate water quality data with other monitoring results to provide a measure of the effectiveness of grazing BMP's.

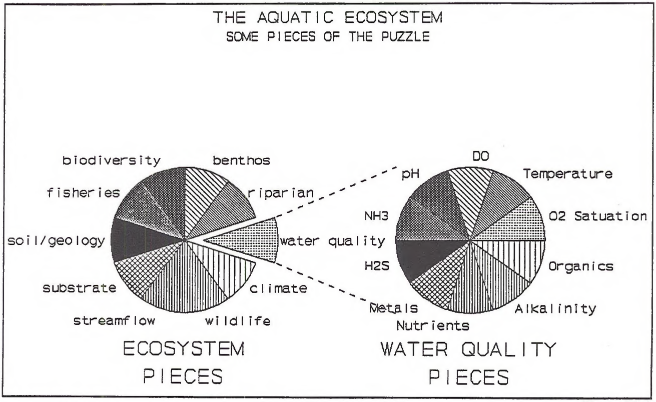

THE AQUATIC ECOSYSTEM
SOME PIECES OF THE PUZZLE
biodiversity
benthos
fisheries
riparian
soil/geology
water quality
substrate
climate
streamflow
wildlife
ECOSYSTEM PIECES
DO
pH
Temperature
NH3
O2 Satuation
H2S
Organics
Metals
Alkalinity
Nutrients
WATER QUALITY PIECES

Figure VI-1

Grazing and Water Quality Impacts

High concentrations of domestic livestock, mainly cattle, have more impacts on the physical, chemical, and bacteriological properties of stream water than most other watershed uses (Meehan and Platts, 1978). Cattle wastes, feces, and urine, deposited in or near streams or entrained or dissolved in runoff reaching the stream, may contribute to nitrogen, phosphorus, and other nutrient concentrations in streams (Doran et al. 1981).

Nutrient loading from livestock waste is an important factor in the pollution of some aquatic systems (Toetz 1971). The high biochemical oxygen demand (BOD) created from such waste products may cause serious oxygen depletion. This is especially deleterious to stream organisms that have high dissolved oxygen requirements (Hynes 1970). Temperature changes further compound this problem as higher temperatures reduce the saturation level of dissolved oxygen in the water.

Cattle wastes may also affect the bacteriological quality of stream water (Johnson and Moldenhauer 1970; Platts 1978; and Ames 1977). Various pathogens from cattle wastes can infect humans, although infrequently, via water-based recreation. Diesch (1970) reported common diseases related to contamination of water supplies from cattle feedlots are salmonellosis and leptospirosis. Kunkle (1970) found an increase in fecal coliform counts when cattle were next to the stream as opposed to farther away. Mack (1974) reported that coliform bacteria can persist and even multiply in natural waters. He noted that multiplication was greater at 35°C than at lower temperatures. Hendricks and Morrison (1967) also reported the enteric bacteria's ability to multiply and grow in cold mountain streams.

Skinner et al. (1972) studying a mountain watershed in Wyoming noted a seasonal fluctuation in bacterial numbers. They found an increasing concentration of bacteria as the snowmelt hydrograph advanced toward its peak. They further speculated that increased bacterial numbers correlated with grazing periods of livestock.

Most investigators rely upon fecal coliform counts as the preferred indicator of bacterial impacts to the watershed from grazing.

Livestock trampling and grazing near streambanks may increase bank sloughing and downstream sedimentation. Grazing also reduces the quantity and quality of riparian vegetation needed as food, shade, and cover for fisheries and other aquatic biota (Platts, 1978). The loss of riparian vegetation produces significant increases in stream temperature (Ringler and Hall 1975). Much of the stream biota evolved in cold streams and thus may be sensitive to temperature increases (Hynes 1970). Modification of the natural stream temperature regime may lead to a considerable change in the composition of the stream biota (Ward 1974). Furthermore, loss of riparian vegetation removes the principal energy source in the form or fallen leaves (Fisher 1972). Increasing turbidity and sedimentation from bank sloughing and erosion will impact several biotic components in the aquatic system.

Water Quality Standards

The State of Nevada as well as the U.S. Environmental Protection Agency (EPA) set standards and criteria for water quality. The methods by which we derive standards vary. However, water quality standards usually reflect toxic conditions that have a rather sudden and lethal effect on aquatic organisms. Acute and chronic toxicity testing is the most common method of deriving water quality standards (Rand and Petrocelli 1985). Acute toxicity testing exposes selected organisms (vertebrates and invertebrates) to varying concentrations of a specific parameter for 96 hours to determine the concentration at which 50 percent of the test organisms die. Chronic toxicity is a fraction of the acute toxicity. The test conditions are such that all environmental conditions except the parameter in question are static. Consequently, these controlled conditions do not test for synergistic effects or when oxygen levels occur at low levels, or within a varying temperature and pH environment. These conditions strongly affect toxic concentrations (Bell 1984).

Because the EPA as well as state agencies recognize the limitations of toxicity-derived water quality standards, they allow for background conditions within specific natural environments. These are site-specific alternative criteria (USEPA 1986) and allow agencies to set water quality standards based on existing or background conditions. Although this improves upon laboratory derived standards and presumably adds protection, such standards still do not address non-lethal biological impacts. Dorfman and Wentworth (1969) showed that lead had varying degrees of toxicity under different oxygen and temperature conditions. Non-lethal impacts such as reduced growth and fecundity occurred at low lead concentrations. Biological impacts may occur even in situations where there are no violations of specific water quality standards.

Water quality monitoring of BMP's tracks conditions in the receiving water as they relate to standards and criteria. Violation of water quality standards clearly indicates the failure of the BMP's. At this point, however, we should also conclude that in addition to the loss of some sensitive organisms, the changing water quality conditions leading up to toxicity have caused non-lethal impacts throughout the aquatic ecosystem. In fact, biological impacts may occur before water quality violations occur (Davis 1975; Combs 1964; Jones 1964). These impacts can be in the form of reduced growth, reproduction, recruitment, fecundity, diversity, or alterations of many other life stage phenomena of vertebrate and invertebrate organisms. BMP monitoring programs which measure water quality impacts as violations of standards only will not identify synergistic or cumulative effects that reduce the overall health of the biotic community.

The assumption behind BMP's is that they will prevent degradation of resource quality. This assumption requires that monitoring programs track several environmental components concurrently. We must, therefore, approach anti-degradation of water quality from the basis of existing conditions with the goal that BMP's will prevent any reduction in the current environmental quality. We must define environmental quality for the whole ecosystem. The integration of single environmental components like water quality, fisheries, habitat, etc., is necessary if we are to measure the anti-degradation effectiveness of BMP's. This means that results of concurrent monitoring programs examined together will identify cause and effect relationships that may not be obvious when examined individually. If we approach BMP monitoring of water quality with this concept in mind then it becomes obvious that maintenance of water quality means more than just staying below the allowable limits of degradation.

Figure VI-2 shows optimum water quality criteria for a coldwater aquatic ecosystem. Information such as this allows comparisons to water quality standards and results of monitoring to examine potential biological impacts. Besides being an integral part of other monitoring programs, water quality monitoring is useful as an "early warning system" of BMP efficiency. Monitoring of fish biology, macroinvertebrates, sediment responses, or riparian habitat, measures changes that may take place over an extended period. On the other hand, water quality changes may occur immediately or in a shorter period. For example, if late spring or early summer water quality monitoring shows that temperature is trending up, and pH and dissolved oxygen are trending down from background or control data, we can predict that the biological community will experience an adverse response. The impact to the stream biota may be particularly severe if the trends are steep or occur during critical life stages such as egg incubation. With this early warning we can either change other monitoring programs (such as redd studies) to evaluate biological responses or, if the water quality changes are extreme, we can order a halt to the watershed activity. Under these circumstances it is unlikely that the BMP's prevent degradation of environmental quality, and violation of standards will occur.

Table VI-5. Optimum Water Quality Criteria, Salmonid Biota

Constituent	Optimum Limits
Ammonia (NH4)	0.0125 ppm (un-ionized form)
Cadmium	0.0004 ppm (in soft water <100 ppm alk) 0.003 ppm (in hard water >100 ppm alk)
Chloride	0.03 ppm
Copper	0.006 ppm in soft water
Hydrogen sulfide	0.002 ppm
Lead	0.03 ppm
Mercury	0.002 max, 0.00005 ppm average
Nitrogen	Maximum total gas pressure 110% of saturation
Nitrite (NO2)	0.1 ppm in soft water, 0.2 ppm in hard water (0.03 and 0.06 ppm NO2-N)
Ozone	0.005 ppm
Polychlorinated biphenyls (PCB)	0.002 ppm
Total suspended solids	80 ppm or less
Zinc	0.03 ppm
Oxygen	6.0 ppm or 95% saturation, whichever is larger
Iron (total)	0.15 ppm
Nitrate	<3.0 ppm
Phosphorus	0.01 ppm
pH	6.5 - 8.0
Carbon dioxide	<10 ppm
Alkalinity (CaCO3)	10 - 400 ppm

Water Quality Monitoring

Sampling Parameters

BMP's dictate the intensity and focus of water quality monitoring programs for a given land disturbance activity and the expected pollutants. There is little point in monitoring heavy metals if these parameters are not a problem now and the land disturbing activity will not contribute heavy metals to the water body(s) in question. On the other hand, if depressed dissolved oxygen levels are the primary concern from grazing activities then intensive, perhaps continuous, monitoring is needed because of the sensitivity of the biotic system to oxygen concentrations.

Therefore, the first step in defining water quality monitoring is to identify the potential pollutants. This can be achieved with water quality models that predict changes in chemical and physical parameters of the receiving waters as a result of the land disturbing activity. Water quality models identify potential impacts, thus they also identify the most appropriate BMP's to prevent or slow the predicted impacts. In the absence of water quality modeling to identify potential pollutants, the most commonly monitored parameters associated with grazing activities are as follows:

pH
Dissolved Oxygen
Temperature
Dissolved Solids
Oxygen Saturation
Ammonia
Nitrogen Saturation
Conductivity
Turbidity
Sediments
Coliform Bacteria
Salinity
Phosphorous Fraction
Nitrogen Fractions
Alkalinity
Biological Oxygen Demand

Sampling Duration

After we identify the parameters for monitoring, the next step is to determine the duration, location, and frequency of sampling. Bearing in mind that most water quality monitoring programs should have a two-fold purpose (early warning of trends and anti-degradation) sampling should occur at least bi-monthly but preferably once a week for the duration of the grazing activity or for at least one full year.

The ideal situation will either allow for a year of baseline data collection in the watershed or there exists extensive background data for the receiving water collected over several years. However, situations such as this are extremely rare and a monitoring program usually does not have a historical data base. Thus, where to establish monitoring sites becomes a key issue. The selection of sampling sites must consider the location of the BMP's to be monitored as well as to compensate for the lack of background data.

Sampling Sites

The rule of thumb for selecting sampling sites is to locate them above and below the grazing area. Figure VI-2 is an example of sample site placement. This will provide monitoring data that measures the effectiveness of the BMP's as the difference in water quality before and after the receiving water meets the grazing area.

We can compensate for no background or baseline data with water quality monitoring at control sites. Set control site outside and upstream of the land disturbance activity. Preferably, control sites are in the same water body and as close as possible to the BMP monitoring sites. Although sampling at control sites will not provide historical data, it will provide a baseline from which to measure the effectiveness of BMP's. Both the control sites and the monitoring sites will be subject to the same natural phenomenon that affects water quality. That is, a dry water year will have essentially an equal affect on water quality at all sites. The monitoring sites, however, will exhibit any additive effects on water quality from inefficient BMP's. Tracking the differences, if any, between the control sites and the monitoring sites on a weekly basis will provide an early warning of deteriorating water quality.

It may not always be possible to establish control sites close to the monitoring sites or even in the same watershed as the land disturbance activity. In this situation, one should select control sites in a nearby watershed on a water body as nearly identical to the monitored water body as possible. Ideally, the discharge, slope, cover conditions, watershed geochemistry and geomorphology will be very similar.

Sampling Frequency

Water quality sampling must be on a regular schedule (described above). at the same depth and time of day. Take stream water quality samples at mid-depth unless the goal of the program is to

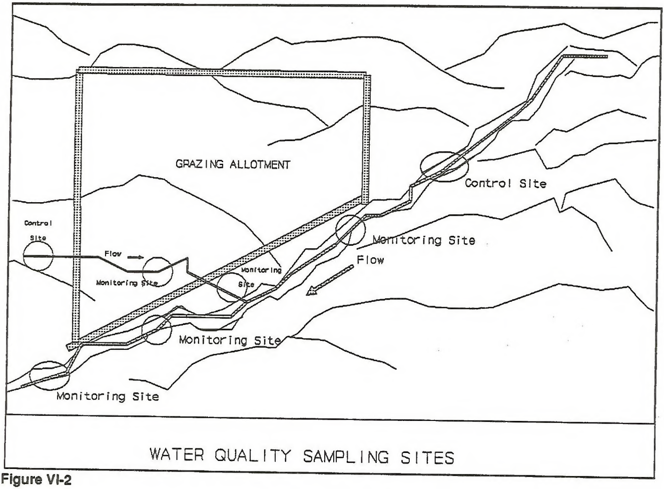

GRAZING ALLOTMENT
Control Site
Control Site
Flow
Monitoring Site
Monitoring Site
Monitoring Site
Flow
Monitoring Site
Monitoring Site
WATER QUALITY SAMPLING SITES

Figure VI-2

identify a discrete mixing zone and requires multi-depth sampling. Sampling at the same site, depth, and time allows for seasonal comparison of results.

Strictly speaking, a sample collected at a particular time and place can represent only the composition of the source at that time and place. However, when a source is fairly constant in composition over time or over distances, then the sample will represent a longer period or a larger volume or both. When a source varies with time, grab samples collected at suitable intervals and analyzed separately can document the extent, frequency, and duration of these variations.

The number of samples required at each site is a function of the confidence interval set for the data. The larger the sample taken, the closer the sample mean and variance. Accordingly, the chance of making an error is less. However, samples cost money. Therefore, we must strike some balance between the cost of sampling and the cost of making an error. The confidence interval makes it possible to estimate the number of samples needed to achieve any given level of precision. Most statistics books contain equations for calculating sample sizes based on confidence limits. Usually the equation is in the form:

$$n = \frac{t^2 S^2}{E^2}$$

where: n = sample number

t^2 = Student's t-Test @ n-1 d.f.

S^2 = standard deviation

E^2 = level of precision = confidence limit spread

Determining the number of samples required using these calculations is tedious and frequently beyond the scope of most water quality sampling programs. Under normal circumstances, three replicate samples taken at each monitoring and control site will be adequate to determine average concentrations and other statistical functions such as standard deviation and variance.

Sample Collection

The goal of sampling is to collect a volume of water small enough to transport conveniently and analyze in the laboratory while still accurately representing the stream. A sample volume of 2 to 3 liters is usually enough. Use a Kemmerer or Van Dorn sampler in deep water and in shallow water use the sample bottle for collecting samples. Before filling, rinse the sample bottle out two or three times in the stream.

Methods of sample preservation are relatively limited and are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce volatility of constituents. Table VI-6 lists some of the more common preservative techniques.

Sample preservation is difficult because most preservatives interfere with some of the tests. Immediate analysis is ideal. Storage at low temperature (4°C) is the recommended way to preserve samples until the next day. This is done with dry ice in a sealed cooler. Use chemical preservatives only when they do not interfere with the analysis. Add them to the sample bottle initially so all sample portions are preserved as soon as collected.

Table VI-6. Water Sample Preservation and Treatment

Constituent	Bottle	Preservation/Treatment
Nitrogen and Phosphorus	Brown polyethylene bottle	Add mecuric chloride and chill on ice to 4 c
Total organic carbon	Oven-fired glass bottle	Chill on ice to 4 c
Dissolved organic carbon	Oven-fired glass bottle	Filter water w/ .45 micron silver metal membrane; 4 c
Organic compounds	Oven-fired glass bottle	Chill on ice to 4 c
Metals	Acid-rinsed polyethylene bottle	Acidify w/ mitric acid to pH <2
Chlorophyl-a	Oven-fired glass vial	Filter onto 0.7 micron glass fiber filter; 4 c
Turbidity	Polyethylene bottle	Chill on ice to 4 c
Dissolved constituents	Appropriate bottles (above)	Filter w/ 0.45 micron cellulose membrane
Bacteria	Sterile Bottle	Chill on ice to 4 c
All others	Polyethylene bottle	No treatment

Critical Water Quality Constituents

Biological communities respond to three basic physio-chemical components in aquatic systems - pH, temperature, and oxygen. All aquatic life forms have evolved tolerance levels for pH, temperature, and oxygen. For salmonid fishes these ranges are relatively narrow (Bell, 1984). Without known toxicants like metals or chlorinated hydrocarbons entering the receiving water, changes in these three parameters will affect biotic health.

The synergism between pH, oxygen, and temperature and most other constituents found in water bodies is an important consideration (Stumm and Morgan, 1970). As temperature increases, both pH and oxygen decrease; the amount of nitrogen and oxygen in solution also changes with changing temperature, and pH determines the availability of nutrients (particularly phosphorus). The interaction of pH and temperature controls the amount of ammonia, hydrogen sulfide, and other gases in solution. Temperature and pH also control the relative toxicity of metal ions. Alkalinity measures the buffering capacity of a water body. As shown in Figure VI-3, the buffering system is a function of pH and the carbonate mole fraction. The higher the buffering capacity (more CO3 available) the less affect many pollutants, such as acid-rain, will have on the stream.

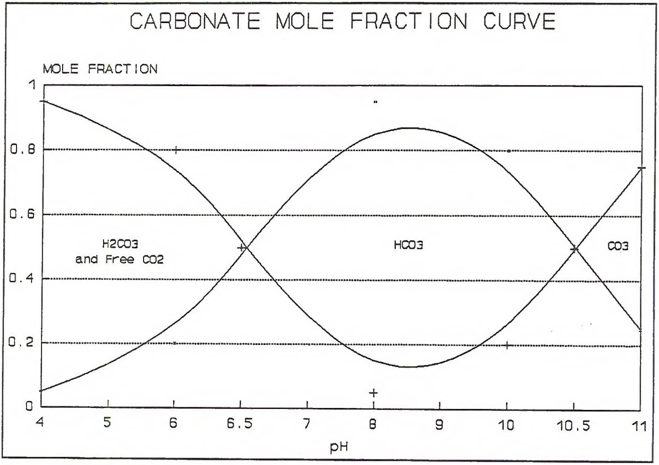


Figure Vi-3

Another set of physical components important in water quality and their effect on the biological community are dissolved solids, salinity, suspended solids, turbidity, and sediments. High concentrations of these parameters can block normal physiological functioning in organisms even under ideal pH, temperature, and oxygen concentrations.

Knowledge of the interaction and synergism inherent in pH to temperature to dissolved gases and conductivity to salinity to dissolved solids, allows us to extrapolate from a very minimal amount of data to reasonably detailed monitoring of critical water quality parameters. The resources (man-hours, equipment, laboratory budget) available to conduct a monitoring program may not allow for anything more extensive than sampling these parameters. Yet monitoring BMP effectiveness is still the goal.

Even if the only tools available are pH, conductivity, and dissolved oxygen meters, one can develop a credible monitoring program. This assumes, of course, that the BMP's are not for metals, toxicants, or other parameters that would require laboratory analysis, and sedimentation is a separate monitoring program. Monitoring many land disturbance activities like grazing requires a modest level of effort.

With only a pH meter, dissolved oxygen meter, and a conductivity meter we can create a data base that compares background conditions with water quality conditions downstream of the grazing area. We can also monitor the effectiveness of BMP's, provide an early warning of degrading conditions, and document violations of standards and criteria. The data base will consist of pH, temperature, dissolved oxygen, conductivity, salinity, percent oxygen saturation, percent nitrogen saturation, ammonia fractions, and accumulative degree days for egg incubation. All of these parameters are particularly critical to the health of the biological community.

Use of Minimal Water Quality Data

We can calculate the following data as functions of pH, temperature, dissolved oxygen, and conductivity.

Percent Oxygen Saturation

Colt (1984) developed tables and easy-to-follow computation methods for dissolved gases. His formulation for calculating percent oxygen saturation is as follows:

$$\%\ O2 = \frac{\frac{[O2]}{BO2}\ (0.5318)}{(BP - PH2O)\ 0.20946} \quad X\ 100$$

where:

$$BP = \text{Barometric Pressure, mmHg} = 2.880814 - \frac{\text{elevation}}{64{,}790.7}$$

[O2] = Dissolved Oxygen Concentration, mg/l
BO2 = Bunsen Coefficient (see tables in Colt, 1984)
PH2 = Water Vapor Pressure (see tables in Colt)

Research (Davis 1975 and Klontz 1985) has shown that salmonids and other aquatic organisms are relatively stress free at 98 percent to 80 percent oxygen saturation. These levels, however, may not be as suitable as those oxygen concentrations that occur naturally. Percent oxygen saturation is a more discrete, biologically relevant measurement of oxygen concentration than dissolved oxygen. Partial pressure (or oxygen tension) determines the "loading" tension of fish blood, that partial pressure of oxygen at which hemoglobin of a particular species is 95 percent saturated with oxygen (Lagler, et al. 1962). Because oxygen saturation is a direct function of temperature and pressure, any small change in temperature will register with oxygen saturation. Consequently, fish respiration and metabolism are more responsive to percent saturation than absolute concentrations (mg/l) of oxygen. Platts (this document) discusses the critical stages of embryonic development and oxygen concentrations.

Percent Nitrogen Saturation

The following calculations are also from Colt (1984).

$$\%N = \frac{BP + \text{delta } P - \frac{[O2]}{BO2}(0.5318) - PH2O}{(BP - PH2O)\ 0.7902} \times 100$$

where: BP = Barometric Pressure (as above)
delta P = Pressure Differential, mmHg (Colt's tables)

[O2] = Dissolved Oxygen, mg/l
PH2O = Water Vapor Pressure (as above)
BO2 = Bunsen Coefficient (as above)

Nitrogen saturation is particularly important to aquatic organisms and becomes toxic, causing gas embolism, at saturations greater than 105 percent. Water will absorb only a certain amount of nitrogen from the air at atmospheric pressure and at a given temperature. When air is under pressure, such as in a deep plunge pool, the water becomes supersaturated with dissolved gases, particularly nitrogen. Sudden warming of water may also cause nitrogen supersaturation.

Ammonia Nitrogen

The un-ionized form of ammonia is toxic to fish and is a function of pH and temperature; however, un-ionized ammonia is not a direct measurement. It is a fraction of total ammonia. The calculations are as follows:

$$\mathrm{Fu(NH3\text{-}N)} = \frac{1}{1 + 10^{(pKa - pH)}}$$

where: $pKa = 0.09018 + \frac{2729.92}{T}$

T = Temperature (C) + 273.2

Fu(NH3-N) = Fraction of total ammonia in the un-ionized form

The total allowable ammonia concentration is therefore equal to the appropriate un-ionized ammonia criteria divided by Fu, the fraction of total NH3-N. To determine the absolute concentration of un-ionized ammonia, the total ammonia must be known which requires laboratory analysis of water samples. Nevertheless, this computation allows us to track increases or decreases in the fraction of un-ionized ammonia. Changes in Fu(NH3-N), particularly large increases, indicate that the potential for ammonia toxicity is increasing. Un-ionized ammonia is also an indicator of organic pollution and serves as a nutrient for nuisance growth of algae and aquatic macrophytes. Although there is still some controversy, most states have established a standard of 0.025 mg/l un-ionized ammonia.

Salinity

Salinity is the total concentration of all ionic constituents present in a water sample. The conductivity of water is a measure of its ability to conduct electricity. It depends on the concentration of ions in the water--the greater the ionic concentration, the greater the conductivity (Boyd 1979). Consequently, conductivity (in umohs/cm) converts to salinity by simply multiplying by a factor of 0.08 to get ppt of salinity.

Dissolved Solids

Total dissolved solids is a measure of the dissolved organic and inorganic matter in water. The inorganic fraction of dissolved solids usually consists of ions and will conduct electricity (Boyd 1979); consequently, we can employ conductivity data as a measure of dissolved solids. Like un-ionized ammonia, this approach is simply a tracking mechanism which allows us to identify increases or decreases in relative dissolved solid concentrations. A high conductivity reading indicates either a high inorganic fraction of the dissolved solids concentration or a high concentration of total dissolved solids. In most situations the latter conclusion is correct because increases in total dissolved solids are normally in proportion to increased organic and inorganic fractions (Boyd 1979).

Phosphorus

Phosphorous is an essential nutrient element and it is one of the least abundant elements if left to natural availability. Consequently, phosphorous is the most common limiting factor in aquatic systems. Due to man's activities, phosphorous is often a pollutant in lakes and streams resulting in over-abundant aquatic plant growth. Phosphorous is not routinely measured in stream studies unless pollution is a problem. Grazing activities on a watershed will mobilize natural concentrations in soil as a result of bank sloughing and runoff from eroded areas. Livestock waste will also contribute phosphorous.

Once phosphorous enters the stream, it quickly transforms into different fractions depending upon pH as shown in Figure VI-4. The form of phosphorous most readily available to plants (algae and macrophytes) is orthophosphate (PO4). Orthophosphate can combine with organic matter and occur in solution or suspension.

If the water quality sampling is limited in budget and equipment, the availability of phosphorous can be tracked by using the mole fraction curve. Although this does not evaluate concentrations of phosphorous, it does allow some insight into phosphorous conditions.

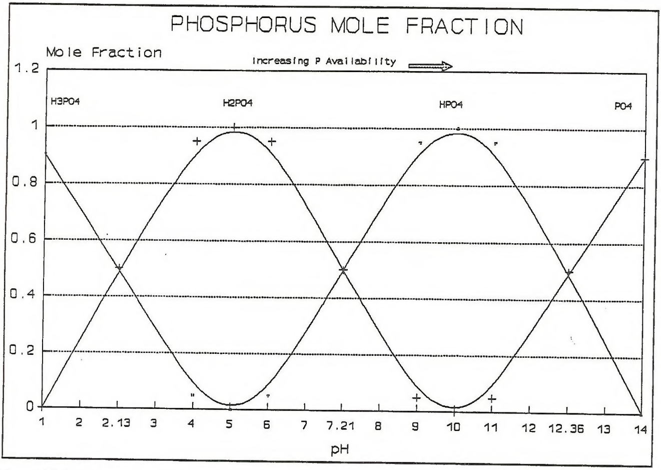


Figure VI-4

Degree Days

The most critical element in fish egg incubation and embryonic development is temperature. All fish species have a range of temperature below or above which incubation is impaired. Within the preferred temperature range, each species exhibits a predictable development rate during incubation. The time required for eggs to reach different development stages (egg eyeing, hatch, yolk-sac, fry emergence) can be measured in degree days (Piper et al. 1982). One degree day is equal to one degree F per day above the base of 32 F. Trout, for example, require 1600 degree days to reach the all-feeding stage. Salmon require approximately 1800 degree days.

Knowledge of the periodicity of the fish species inhabiting the water body allows us to calculate the normal degree days (from control site data) required to reach different development stages.

We can compare control data to calculations for the monitoring site. Fish can detect and respond to temperature changes as small as 0.5° C (Bell, 1984) and any temperature difference between the control and monitoring sites will have an effect on incubation. If the BMP's allow for an increase in temperature, all incubation stages will accelerate and fry emergence may occur earlier than usual. This may represent a substantial biological impact if emergence occurs before the normal food base (protozoan and macroinvertebrate) has developed. If, on the other hand, temperatures are lower than normal, incubation will slow and fry emergence may occur during low water periods when the risk of predation is highest.

Calculation of degree days and plotting the accumulative degree days from spawning to emergence for the control and monitoring sites will identify potential impacts to fish incubation as a result of ineffective BMP's.

Integration of Water Quality Data

Water quality data by itself has rather limited application. We can certainly determine water quality violations and we can see trends and changes as they occur. However, these applications do not describe the biological significance of our observations. Pool the results of all BMP monitoring programs so data can be viewed collectively. Water quality is an essential part of the entire BMP monitoring program. Compare the data to habitat studies, fisheries monitoring, benthos sampling, and others to identify cause and effect relationships.

For example, results of fisheries studies may indicate some reduced growth and lowered recruitment in the monitored zone. Macroinvertebrate data may show a species shift and reduced diversity while habitat studies show essentially no change in quality and sediment inputs may not have increased. If water quality monitoring indicates a drop in percent oxygen saturation, combined with somewhat elevated temperatures and increased ammonia fractions, we could conclude that water quality has degraded sufficiently to induce stress on the aquatic biota resulting in some minor but significant biological responses. This method of integrating data from all monitoring programs would then allow us to refine monitoring goals and begin to focus on specific problems to refine or change BMP's.

Although the forgoing example is rather simplistic, the idea is clear. Water quality is an essential part of the ecosystem; it is not an independent ecosystem. Monitoring of BMP's is only as effective as the methods employed and how the monitoring results are interpreted.

STREAMFLOW DETERMINATION AND EVALUATION

Problems

Understanding flow effects or how to mitigate for effects in flow-altered streams is complicated, because of the high variation in geology, climate, terrain, hydrology, and disturbances by man. Such constraints necessitate detailed understanding of the natural functioning of ecological systems, their probable behavior under various resource development programs, and their ability to continue functioning indefinitely under whatever management scenarios are employed.

Methods are available to assess certain instream requirements, for the *short term*. These short-term assessments are mainly for water quality, recreation, fisheries, wildlife, and forage needs. These methods are very site-specific with short-term, narrow horizons. Seldom do they relate to the long-term needs of valley bottoms and riverine-riparian types. Fisheries habitat, channel maintenance or wetted perimeter flows by themselves, will not maintain many of the valley and riverine-riparian forming processes. This level of flow recommendation can result in degradation or loss of riparian habitat and valley form which, in time, will result in loss of fish habitat and fish populations.

The burden of developing streamflows in large watersheds based only on a relatively small number of site-specific data or criteria, is very difficult. Processes and relationships that are clear in one part of the watershed may be uncommon in other parts of the watershed. These spatial and temporal interrelationships are simply too complex to allow the development of effective quantitative geographic predictive schemes without a qualitative understanding of the watershed patterns and process.

Criteria and Objectives

The criteria for developing valley-stream flow methods are:

1. Information gathering must meet the realities of time and money.

2. Problems of extrapolating data and information from one area to another area with confidence must be solved.

3. Agreement must be gained on what procedures and variables to use in the analysis.

4. The volume of data must be processed and analyzed without confusion.

To meet these criteria, specific objectives are:

1. Construct a classification system to eliminate variability in valley stream reaches.

2. Design the data collection to fit the classification format.

3. Integrate classification and hydrologic models into a flow analysis procedure.

4. Determine required flows.

5. Evaluate the effects if recommended flows are not met.

The four flow groups to be analyzed are: (1) peak flood flows that maintain the valley forming processes; (2) riverine-riparian flows that maintain the riverine-riparian habitats, adjacent upland habitats, water tables, and soil saturation zones; (3) channel maintenance flows that keep streambanks and channels functioning; and (4) instream flows (IFIM derived flows) that meet short-term fish survival needs.

Maintaining ecological integrity of valley bottoms is the principle, overriding factor for determining streamflows. Natural flows constructed the valleys and streams and gave them form and condition. Consequently, instream, channel, riparian, and valley flows are all needed in combination to maintain fishery resources.

Channel Maintenance Flows

Channel maintenance flows are established to control the condition of the channel substrate and the location and condition of the channel and bank vegetation. The application of these procedures does not result in a description of any special purpose flows such as those for fishery, streamside habitat maintenance, water quality, recreational, or aesthetic considerations. The calculated flows are designed to maintain only the active channel.

Channels are different over space and may require different flows for different reaches for maintenance of a desired condition. Thus, there is the need for Valley Bottom Types (VBT's) to examine all channel types within a basin so flows can be set on those types that are the most critical.

Usually in channel flow studies, it is a given that the present channel should be maintained in its current form. Flows then are needed to ensure that; (1) bar surfaces do not experience changes to more xeric plant species; (2) sand and silt does not accrete on the channel; (3) back-channels are not abandoned; (4) tributary confluences do not aggrade main channels; and (5) widths are not reduced.

Sediment depositional problems are one of the major items addressed. Recent studies (Reiser et al. 1985) show that fine materials can be removed from the upper portion of the channel substrate without disrupting the armour material. This again, refers to flows that maintain channels in existing forms but changing condition.

Most channel maintenance flow methods suggest that bankfull discharge is the simple discriminator between channel-forming and floodplain-forming processes. This concept has little value when analyzing flows for floodplain maintenance. Chorley et. al. 1984, in studying 36 active floodplains showed bankfull recurrence intervals to vary between 1 and 32 years. Other investigations have been directed at establishing those flows that would maintain channels as they related only to fish. This is but a small fraction of the resource that needs protection.

Riverine-Riparian Flows

Once the stream overtops its banks the amount of usable habitat the water affects increases rapidly. Riverine-riparian and floodplain flows are used synonymously even though elevated floodplains could require higher flows. The difference does not warrant determining both flow needs.

Overbank flows are erroneously simulated as within-channel flows. This error does not give flow recognition needed to maintain the floodplain. Floodplains include side arms, oxbow lakes, marshes, swamps, ponds, and the network of tributary streams within their inclusion. To date there are no state-of-the-art methods for determining flows needed to maintain riverine-riparian habitats and their surrounding floodplains and terraces. It is a given that floodplain maintenance requires that the floodplain receive flood water at selected intervals to function properly. As shown in Figure VI-5, these flows are the peak of the hydrograph and within the Q2 to Q10 range. The vegetative cover is also determined by these flow processes.

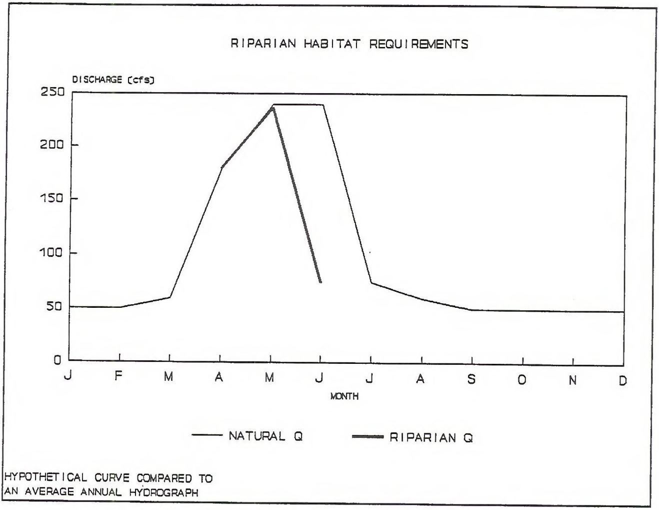


Figure VI-5

Valley Maintenance Flows

Determining valley maintenance flows requires using the pulsing concept spread out over spatial and temporal needs. Flow levels will take care of many spatial needs but pulsing analysis will be needed to determine long-term habitat needs. In many streams pulsing can have much more effect on stream productivity than the nutrient spiralling discussed by Vannote et al. (1980) in the river continuum concept. Energy and materials move between the valley and its stream.

The valley maintenance flow is critical to the maintenance of its riparian systems. Valley floor gradient and width, elevation, fluvial processes, and soil parent material are important in this relationship. These factors fall out and are described by the classification system.

Climatic variability, expressed through water flows working on geologic structure as modified by vegetation, determines valley form and condition in both natural and artificial systems. Series of very large hydrologic events affect valley sides, and smaller flow events affect channels and floodplains; both, over the long-term, affect valley form.

Valley Bottom Types (VBT's) become very important in determining required flows. The steeper the valley slope, the greater the sheer stress per unit of down-valley water flow. Also, the narrower the valley width, the less horizontal distance the flows migrate. Changes in valley form or slope are long-term adjustments as usually immense quantities of materials and vegetation patterns must be redistributed or changed. Some of the forms and conditions are still under the influence of past pleistocene events. Other processes must go on for years to develop certain form and condition.

The Approach

The recommended procedures for determining flows and flow processes needed to maintain valleys and their streams in productive condition uses land classification, a historic approach when flow records are sufficient for analysis, and hydrologic measurements and models. Historical analysis is dependent on USGS gage flow records being adequate to synthesize the necessary hydrologic information.

The flow determination process requires that the analysis steps be completed in proper order of sequence. Field and statistical testing will still need to be done to fine tune the results. Time frames and budget limitations are constraints on the methodology.

The methods are driven by four types of flow levels: (1) fish maintenance; (2) channel maintenance; (3) riverine-riparian zone maintenance; and (4) valley forming process maintenance. The flows are described as:

Fish Maintenance Flows

This flow level is the minimum flow necessary for providing habitat conditions necessary for short-term fish survival. This flow will not allow for long-term maintenance of fisheries habitat. Neither will it allow for the maintenance of channels, riparian areas and valley form.

Channel Maintenance Flows

These flows maintain the channel and immediate adjacent vegetation. They prevent the encroachment of vegetation into the channel. These flows also maintain the desired channel substrate condition and adjacent streambank form. This flow is of sufficient magnitude and duration to flush sediments from pools and the interstices of rearing and spawning substrate. Flows to maintain off-site riparian vegetation, flood terraces, and valley forming processes are not included.

Riparian Maintenance Flows

These are overbank and over-floodplain flows that are needed for the establishment and maintenance of off-channel riparian and aquatic habitat. Protecting off-bank riparian vegetation and continuation of valley bottom soil development is important because this vegetation and its soils, over the long-term, control future channel location and instream habitat.

High flows are required during normal snowmelt periods to transport and plant seed. These flows provide the local channel disturbance and deposition (site preparation) for regeneration of vegetation along banks. These high flows will also destroy or "brush back" vegetation attempting to become established in the bed of the channel. Xeric vegetation, always attempting to gain dominance on the floodplains, will be set back.

This flow recharges underground storage water in adjacent riparian systems and provides the medium for inorganic sediment and organic energy transfer between riverine and riparian ecosystems.

Valley Forming Flows

These large infrequent flows are those overbank, over-floodplain, and over-terrace flows that are needed to maintain channel patterns, riparian areas, and buffer hillslope infringement processes. Valley forming flows are required to maintain VBT'S that have extensive off-channel riparian, aquatic, and meadow habitat and high rates of colluvial slumping or other mass wasting processes.

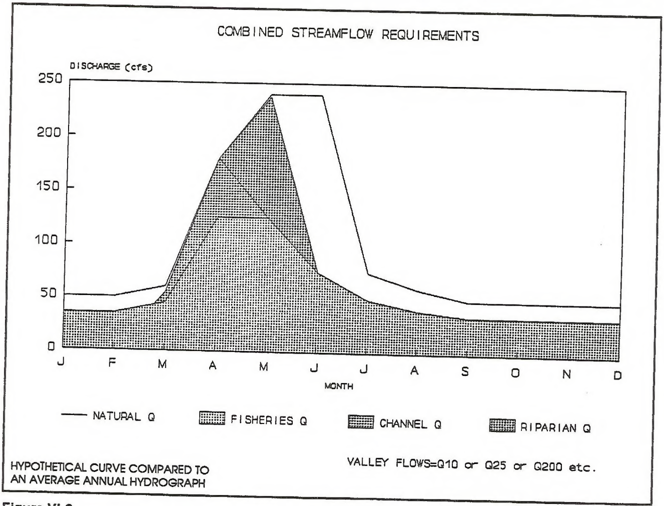


Figure VI-6

Conceptually, the four flow requirements are illustrated in Figure VI-6. Flow magnitude increases from flow regime 1 (fish maintenance only) to flow regime 4 (valley process maintenance). IFIM-derived fish maintenance flows carry fish mainly through low flow conditions. Seldom would IFIM flows be a restriction during moderate to high flow regimes. IFIM methodology enters in to determine base flow needs, particularly in late summer and fall.

The channel maintenance flows are those flows that supposedly maintain natural vegetation along the channel sides. In so doing they provide linkages for long-term maintenance of channel characteristics, including in-channel fish habitat. Streamside vegetation provides numerous functions (i.e., root strength to hold banks together, channel roughness to slow flows, shade for temperature control in summer and winter, litter inputs from leaf fall, and large organic debris) important to the character of the stream and streambank riparian areas.

That vegetation closest to the channel is generally of greater importance to fish than vegetation further from the channel. For wildlife and other resources the opposite is often true.

It is expected that a flow slightly larger than the average annual peak flow (i.e., approximately a Q1.5 or Q3 flow) would be of sufficient magnitude to provide for long-term continuity of the channel and immediate adjacent vegetation. The Q1.5 (often referred to as the dominant discharge flow) peak flow is assumed to represent bankfull flow for those channel reaches having surrounding floodplains. In reaches without gaging stations, the elevations of streambank tops and the "unvegetated" portion of the channel are field indicators of channel maintenance flow levels.

For those channel reaches where off-channel riparian habitat exists, flows exceeding the Q1.5 average annual peak discharge are exceedingly important for the continued maintenance of riparian habitat. Without such flows the riparian areas would revert to plant communities more indicative of upland conditions. Overbank flows are important for recharging local water tables, filtering sediments, and retention of nutrients. Over time peak discharges in the Q5 to Q20 range may be necessary for riparian maintenance flows depending on the VBT.

Establishing channel and riparian maintenance flows are important components in establishing the character of stream channels, fisheries habitat, and adjacent riparian vegetation. However, flows alone are not capable of maintaining a healthy stream ecosystem. Management activities along stream margins are also of fundamental importance. If improper grazing, over-harvest of timber in the riparian zone, vegetation conversions from shrubs to grasses, roading, and agriculture have impaired the quality of riparian vegetation and local hydrology, then maintaining flows at some desired level may be of little benefit.

In some cases all the natural flows may be needed to allow rehabilitation of degraded riparian habitats. Only after riparian areas are improved would the use of flows for other benefits be warranted.

Valley forming flows are identified as those peak discharges that usually exceed Q25. This flow regime is more difficult to establish in many VBT's as many valleys have been formed by factors other than fluvial processes, such as glaciers, faults, and lava flows. The determination of this flow must be done with reason. Over long periods (thousands of years) the historic flows that maintained the present valley may now destroy roads, homesteads, irrigation works and other property. Valley forming flows will need to be evaluated in a shorter time frame. If, however, the intent is to set "in time" flows needed to maintain valleys considering the future demands on this water, then there is a need to set total flow needs.

Step Sequences for Flow Determinations

Step One - IFIM

In many stream reaches, flow recommendations resulting from IFIM (Integrated Flow Incremental Method) analysis will be adequate to maintain fisheries as well as channel and riparian resources. These reaches will generally occur in V- and notch-shaped valley bottoms where riparian habitat is sparse and channels are formed by steep, rock sidewalls.

Step Two - VBT Classification

The recommended classification approach delineates VBT's to reflect terrestrial and aquatic factors controlling their condition over time and space. VBT's are used instead of riparian habitat types because current riparian zone classifications present only vegetation condition in its existing state. Vegetation often hides those conditions that are more important to the classifier. Form itself may actually supply the limiting factor to the resource being evaluated. The VBT integrates form, soils, and vegetation.

Geology is identified in the upper hierarchical layers and its influence on streamflows is incorporated prior to the VBT level of resolution. Geomorphic form is the most important element used to develop this classification, because geomorphic processes control how water and sediments move through the VBT's. The Subsection and Landtype Association levels explain much of the geomorphic processes and the VBT level accounts for the remainder needed to identify streamflows. With experience it is probable that each VBT, by itself is able to provide the information needed to determine the flows it needs to maintain productivity, thus, eliminating the need for large data bases.

Classification Procedures

The many different types of watersheds, streams, and VBT's require some method of stratification where known reference site information can be analyzed and findings extrapolated over the entire drainage areas. With a Land Systems Inventory in place, or a similar stratification system, the necessary maps and photographs (aerial) are available to refine the interpretations. The VBT's, however, still need to be delineated on the maps and identified and described. This can be done quite accurately on maps or aerial photographs as small as 1-24,000 scale. But, because of usual funding restrictions restricting the number of classes of VBT'S that can be identified, the scale will usually have to be larger. The VBT mapping can be done successfully on a 1:250,000 scale.

Classification Format

The proposed classification format uses the Land Systems Inventory (Wertz and Arnold 1972). Maps will be stratified and delineated by Section, Landtype Association, and VBT. The format is shown in the following table.

TABLE VI-7. CLASSIFICATION FORMAT

Category	Description
Section	A major component of an Ecoregion (Domain) comprising relatively homogeneous parent materials. Distinguishable from surrounding sections by structure, degree of weathering, dominant particle sizes, and hydrologic characteristics. This ecoregion level bands together uniform landforms at the level of Hammond's (1970) land-surface form regions.
Landtype Association	A major subunit of a Sub Section (Sub-section is similar to a geologic district) that derives its overall physical structure from a single dominant geomorphic mechanism. A Landtype Association is made up of associations of landtypes within a single geologic type. An association contains recurring patterns of landforms, soil, and vegetation.
Valley Bottom Type	A subunit of the Landtype Association determined by local structure which correlates with areas of similar associations of soil and plant communities. The type is identified at the level of Daubenmire's (1952) habitat types. VBT's have similar soil series or families with similar plant communities. Hillslope landtypes above valley sidewalls are ignored at this stage.

At the Section level uniformity in land forms at the level of Hammond's (1970) land-surface form is evident. This level can assist in developing broad level flow interpretations, but not for drainage area level interpretations. At this level the first appearance of resultants from geo-climatic interaction occurs. This level is used to eliminate variation in streams over large land areas so the resulting more similar groups can again be stratified at the Landtype Association level.

At the Landtype Association level, groups of closely related geomorphic types with recurring patterns of land forms, lithology, soil, and vegetation series are identifiable. This is the first stratification level where flow effects and needs can begin to be addressed. Individual lithologies, stream habitats, and mosaics of vegetation are now evident. This level is used to further stratify the stream reach types to eliminate environmental variation. The VBT level groups neighboring phases that belong to the same soil series with similar plant communities and valley and channel form. Geomorphic processes are now similar within similar types. Soil texture is determined. Similar VBT's contain closely related riparian and riverine aquatic habitat types. Streambank and channel types are displayed with degree of channel incision or confinement determined. This level maps mainly by geomorphic form and, erosional and depositional process. At this stratification level flow responses can be identified and cumulative effects can be aggregated to cover basin needs.

VBT'S are mapped using mainly qualitative input with some quantitative input from exisiting data banks. Qualitative means the use of expert judgment backed by many years of experience. This large base of experience is used to classify the VBT's. This requires interactive expert judgment and an understanding of the relationships among environmental controls.

The classification coding format is:

The first zero (0000) identifies the Section.
The first and second zeros (0000) identify the Landtype Association.
The third and fourth zeros (0000) identify the Valley Bottom Type.

The Section level of classification separates lands on their similarities and differences in geology, climate, degree of parent material weathering, and some hydrologic characteristics. Example Sections for the Nevada drainages are:

(1000): Great Basin Ranges
(2000): Great Basin Basins
(3000): Mohave Lowlands

Each Section is classified to the Landtype Association level using the Land Systems Inventory approach. Stream similarities and differences caused by geology, climate, elevation, vegetation are identified. Most landform influences will now be accountable. Streams are now grouped under a single dominant geomorphic process. Example Landtype Associations in Nevada are:

(1100): Heavily Glaciated Basins
(1200): Heavily Glaciated Trains

(2100): V-Dissected Fluvial
(2200): V-Moderately Dissected Fluvial
(3100): Broad Low Gradient Depositional

Streams within each Landtype Association are classified into their respective VBT's. VBT's are identified and mapped based on structural and functional differences in the VBT within a Landtype Association (Cole 1972). Example VBT's in Nevada are:

(1101): *Glacial Basin* - A zone of glacial erosion in headwater areas. Water movement is through riparian zones to streams. Therefore, flows higher than channel maintenance flows may not be needed. Glacial basins mainly contain 1 and 2 order streams. Therefore this VBT may not be needed if only stream order 3 and higher are evaluated.

(2101): *Glacial Basin* - Same description as 1101 except within the 2100 Section - Landtype Association.

(1102): *Glacial Train* - A zone of glacial material transport. Floodplains and levees are usually confined between lateral moraines. Substrates are generally large and permeable. Alluvial aquifers generally fill from the bottom up. The function of riparian flows is for sediment accrual, and is not needed for groundwater recharge. Fish, channel, and sometimes riparian flows are all applicable to the maintenance of these VBT'S.

(2102): *Glacial Train* - Same description as 1102 except within the 2100 Section - Landtype Association.

(1103): *Glacial Outwash* - A zone of glacial material deposition. Course-textured glacial outwash fills the valley bottom. This bottom may be flanked by extensive alluvial fans. Streamflow is depleted by excessive bedloss. Channels tend to be altered each year by anchor ice flows. These anchor ice flows may not be entirely natural and may result because of a deteriorated habitat condition. Some degree of fish, channel, and riparian maintenance flows are applicable.

(2103): *Glacial Outwash* - Same description as 1103 except it lies within the 2100 Section - Landtype Association.

(1204): *V-Shaped Erosion Canyons* - This VBT is heavily modified by fluvial erosion. The VBT contains steep gradient streams flanked by steep side slopes. Riparian habitat is often absent or very limited. Riparian vegetation is generally composed of large shrubs or trees whose roots can penetrate to the water table. Riparian vegetation is naturally scarce in many areas but overall was probably much more abundant in the natural state. Riparian and valley maintenance flows are usually not required.

(2205): *V-Shaped Erosional Canyons* - Same description as 1204 except it lies within a 2200 Section - Landtype Association.

(3206): *V-Shaped Erosional Canyons* - Same description as 1204 except is lies within a 3200 Section - Landtype Association.

(1307): *V-Shaped Depositional Canyons* - A zone of fluvial deposition of sediments. Contains moderate gradient streams flanked by floodplains and levees. Riparian habitat may be extensive. This VBT may occur in conjunction with structural fault formed valleys. Streams may be bordered by agricultural lands. Fish, channel, and riparian flows are applicable.

(2308): *V-Shaped Depositional Canyons* - Same description as 1307 except it lies within a 2300 Section - Landtype Association.

(3309): *V-Shaped Depositional Canyons* - Same description as 1307 except is lies within a 3300 Section - Landtype Association.

(1410): *Alluvial Valleys-Confined Floodplain* - This VBT corresponds with broad structural valleys formed by faults. Most of the valley bottom is overlain by an upland alluvial fan that confines floodplains, levees, and riparian habitats. Streams usually run perpendicular to the axis of the basin.

(2411): *Alluvial Valleys-Confined Floodplain* - Same description as 1410 except it lies within a 2400 Section - Landtype Association.

(3412): *Alluvial Valleys-Confined Floodplain* - Same description as 1410 except it lies within a 3400 Section - Landtype Association.

(1413): *Alluvial Valleys-Unconfined Floodplain* - This VBT occurs in broad structural valleys. Riparian floodplains and levees are less confined by alluvial surfaces (upland). The main difference between confined and unconfined is in the width of the riparian habitat. Unconfined floodplains usually occur in higher order streams than confined. Usually streams within the VBT run parallel to the axis of the structural basin.

One dominant VBT (the critical VBT) may be assigned for each stream reach rather than splitting stream reaches into discrete VBT's. This needs to be examined during the first phase of the classification-flow determination process.

Aerial photographs and topographic maps will be used to enhance mapping capability. To map VBT's a plot of stream reaches with arc attributed numbers are needed from the USGS. An arc attribute table with stream order, channel gradient, valley width, etc., is needed for each stream reach. Maps of 1:250,000 scale, 1:24,000 scale and aerial photographs of 1:24,000 to 1:60,000 scale are needed. The Land Systems Inventory maps already completed by the U.S. Forest Service would be used in the mapping. The Land Systems Inventory, as now mapped, may need some minor revisions to fit the needs for VBT mapping.

The VBT's group all stream reaches into physiographically and ecologically discrete units. The VBT designations are an important linkage to the flow regime information because they allow specific flow requirements to be associated with a given VBT. Again, VBT's are capable by themselves, once experience is gained, of determining their own flow requirements. At this stage of flow determination development, however, other data and analysis procedures will be needed to gain accurate estimates.

The VBT will be used to determine which one or which combination of the four flow regimes the respective stream reach will need to maintain its productive potential. In some VBT's the channel maintenance flow will be the highest flow needed to maintain the limited amount of streambank and riparian habitat present. Not all VBT's will require a riparian flow level, let alone a valley maintenance flow level. For example, deep V-shaped erosional canyon VBT's have only narrow lines of bordering riparian vegetation and small narrow streambanks, if any at all. These VBT's may need only fish or channel maintenance flows capable of handling colluvial inputs.

Broad alluvial valleys, however, with bordering ponds, marshes, oxbows, channel cut-offs, and wide riparian zones could easily need all of their valley forming flows to maintain these surrounding environments. When one of the flow types is selected (i.e., valley maintenance flow) this automatically takes care of all other lesser flow levels during the time period this flow is in effect. If a riparian maintenance flow level is recommended for the VBT from May through June, then those flows needed for fish and channel maintenance are automatically included.

The VBT will have accounted for the influences for most inventory variables collected, except for basin drainage area, drainage density, and stream order. Of the three, drainage area would be the best variable to account for differences and similarities resulting from stream size. If verification shows that stream size is not sufficiently accounted for at the VBT level, then drainage area will be used to account for differences in stream size. The drainage area stratification levels will be:

1. 1 to 25 square miles
2. 26 to 100 square miles
3. 101 to 500 square miles
4. 501 to 1000 square miles
5. 1001 to 5000 square miles
6. Over 5001 square miles

Drainage area will be recorded for all sample sites and worked into the analysis from the attribute level even if not used in the classification. In the actual field analysis, stream size is accounted for by actual physical measurements. Also those VBT's covered by gaging station information would have stream size already determined. Stream size (basin area) may have to enter into the analysis on those VBT's where information is being interpolated from studied VBT's. The USGS, however, has the capability of providing flow hydrographs for most sites. The accuracy of this hydrograph would vary as distance from a gaging station increased.

Example of classification levels:

	Levels	*Number*
I.	Sections	10
II.	Landtype Associations	10
III.	Valley Bottom Types	20

Once a subset of samples from the same VBT group (there could be as many as 20 different groups) has been studied, variation determined, and flow needs interpreted and found satisfactory, this information will be extrapolated to those same VBT's types located throughout the drainage that are not sampled. There will also be a need to determine which VBT within a stream or stream reach is the critical habitat as related to flow needs. For example, if a V-Shaped Depositional VBT occurs below a V-Shaped Erosional VBT (the erosional type requires less riparian maintenance flow) the former may dictate that a higher flow is needed through the complete reach. Also, some VBT's, such as Glacial Basin or Glacial Train will only need fish or channel maintenance flows. Their water tables fill from the bottom up and water flows through the riparian system to the stream. Therefore, valleys and riparian systems take care of themselves and are not dependent on the stream for maintenance processes.

Step Three - HEC-2 Measurements

One method used to describe water surface elevation and discharge is the HEC-2 hydraulic simulation model. This model allows us to calculate the discharge necessary to meet bankfull flow levels and to maintain and influence floodplains and side terraces.

HEC-2, however, is not the only step-backwater model which can perform these calculations. Other models are available and, with testing, something other than HEC-2 may be more appropriate - slope:area curves for example.

HEC-2 transects should be established on each of the IFIM sample reaches. The number of transects will depend upon the channel configuration and hydraulic controls present. Each transect will cross the stream and extend over both sides of the valley bottom to the furthest influence of streamflow, at least to the 100-year flow event elevation and the extent of riparian vegetation.

As shown in Figure VI-7, HEC-2 calculations using elevations and the energy slope will determine the discharge (cfs) needed to attain any height above the streambed. Thus we can determine the discharge required to maintain the channel and the existing riparian habitat. The percentage of the riparian habitat dependent on a discharge at any terrace will also be known.

Historic Analysis

An initial, historical, analysis stage will provide experience and familiarity with VBT's and flow functions. Historical aerial photographs will indicate whether the VBT has changed states over time. Identifying changes in state over time will improve our understanding of those flows and processes that built and currently maintain the VBT.

The first VBT's analyzed must be on gaged sites or close enough to use historical gage data. Historical discharge data will allow testing of the first interpretations. The HEC-2 approach can simultaneously be tested with gage data. During this initial stage more than one method (slope-area curves, other step-backwater models) should be used for determining non-fish flow requirements. This will allow comparison and testing of the models against each other using historical discharge data.

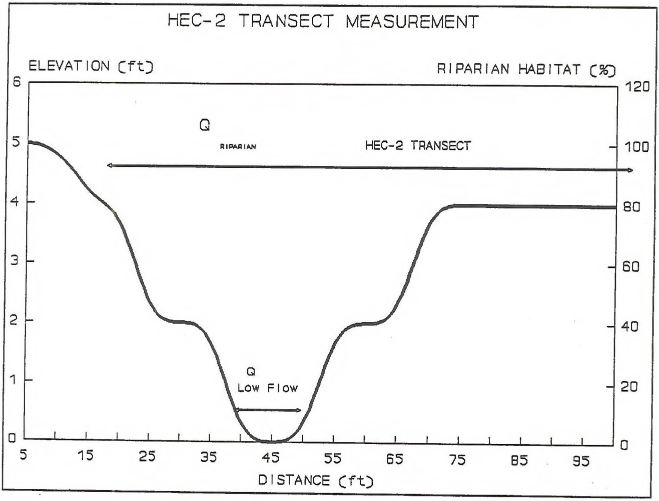


Figure VI-7

Step Four - Average Annual Hydrograph

The final recommended flows for each VBT will be displayed on three flow level-duration graphs. One graph will display "when and how much" flow is needed over the average water year. The second graph will display "what" flow levels are needed over time (at least through the next 25-year interval). The third graph will display the annual duration time needed for each flow level recommended.

As shown in Figure VI-8, the flow information required to develop flow recommendations begins with an average annual hydrograph for each VBT. The annual hydrograph curve shows the seasonal pattern of discharge in the stream reach. The curve indicates the magnitude of peak discharge and low flows by month as well as the increase and decrease rates on the rising and descending limbs of the hydrograph. Knowledge of the periodicity of the spring freshet and summer low flow months is essential to recommending all streamflows.

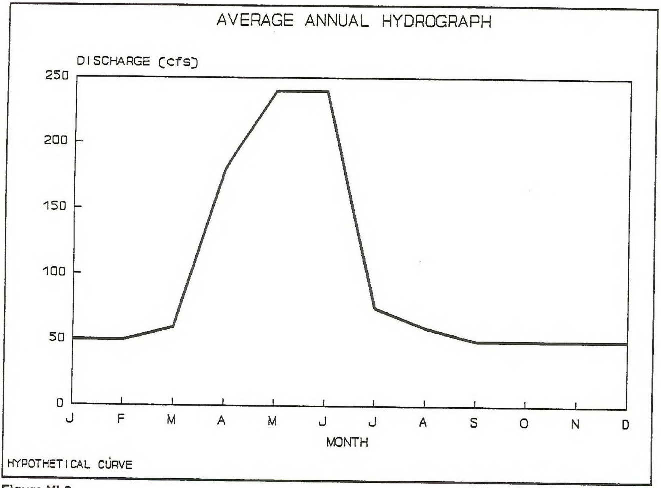


Figure VI-8

Rosgen (1986) suggests that the rise of the hydrograph in the spring is critical to maintaining channel morphology and removal of sediments and fine material. Rosgen also suggests that the falling limb of the hydrograph is less critical, in terms of its energy potential, and that a 10 percent per day drawdown rate is adequate. We agree that the rising limb is most critical and this is the period in which to establish channel maintenance, riparian, and valley process flows. However, we recommend a drawdown rate equal to 90 percent of the previous day's discharge. This will ensure that water remains in contact with riparian vegetation long enough to allow for better seeding and germination. Saturation of the root zone and recharge of the groundwater aquifer are also important processes requiring extended contact time with flood flows.

Step Five - Frequency of Occurrence Curve

The results of HEC-2 measurements and calculations indicate the discharges necessary to meet channel and riparian flow needs. The average annual hydrograph indicates the time of year these flows are needed. However, HEC-2 results and the average annual hydrograph cannot tell us when these flows occur because most riparian flow requirements will exceed the average annual flows. The frequency of occurrence curve (Figure VI-9) is based on the return period (years) of flows and indicates when the recommended flows will occur in time.

For example, on a selected reach our IFIM and HEC-2 analyses show that 125 cfs is the recommended channel maintenance flow, 175 cfs is the recommended minimum and 225 cfs the maximum riparian maintenance flow, and 400 cfs is the recommended valley maintenance flow. The frequency of occurrence curve shows that these flows correspond to the 2, 5, 10, and 25 year return periods or Q2, Q5, Q10, Q25, respectively. Therefore, we know that the flows necessary to maintain the channel in this reach occur every two years while the riparian flows occur every 5 to 10 years, and the flow necessary to maintain the valley processes occurs every 25 years.

This information verifies that our flow recommendations do occur in time - although not as average annual events - and that the current channel, riparian, and valley conditions are dependent upon these flow return periods.

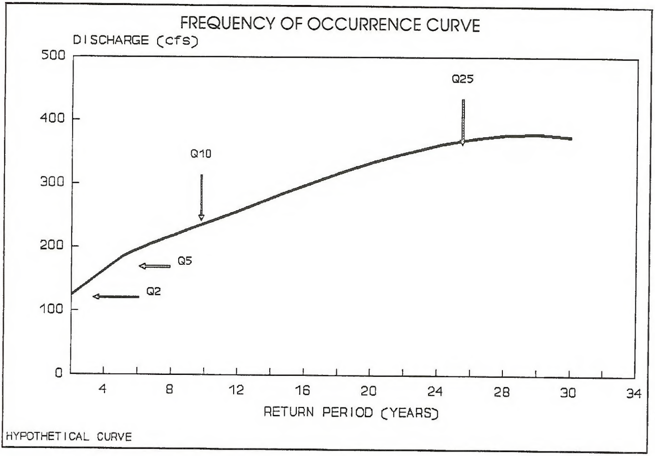


Figure VI-9

This information is also important during flow negotiations. The negotiators must know what is involved in tradeoffs. A recommendation of 175 cfs for riparian maintenance may be negotiated to 150 cfs. As shown in Figure VI-9, these negotiations will essentially eliminate riparian habitat because the 150 cfs equates to a Q3 and the riparian habitat requires a minimum Q5 flow.

Step Six - Flow Duration Curve

The scientific literature is silent on riparian hydrodynamic and hydrostatic issues. There has been little research into the amount of flood time required for riparian species to produce seed and germinate (hydrostatic issues) or the amount of time flood flows are required for nutrient cycling and sediment exchange in the riparian zone (hydrodynamic issues). In the absence of this type of research information, we can approach the amount of time flood flows must be in contact with the riparian habitat by using flow duration curves.

The flow duration curve shown in Figure VI-10 indicates that the recommended flows for channel maintenance (Q2), minimum riparian (Q5) and maximum riparian (Q10) maintenance are exceeded in the stream reach 30 percent, 20 percent, and 10 percent of the time, respectively. Since our data is based on empirical HEC-2 measurements, it is logical to assume that these flows are currently maintaining the resources.

The exceedence values can be converted to time so that Q5 lasts for 7.3 days, Q10 lasts for 3.7 days, and Q2 lasts for 18.2 days. This information will allow us to refine flow recommendations so that the duration of flood flows is incorporated either as a specific time or as a drawdown rate described previously.

Estimating flow duration for channel, riparian, and valley maintenance in this manner may not be as accurate as research-derived hydrostatic and hydrodynamic data but in the absence of such data it is a measurable, quantifiable, and defensible approach.

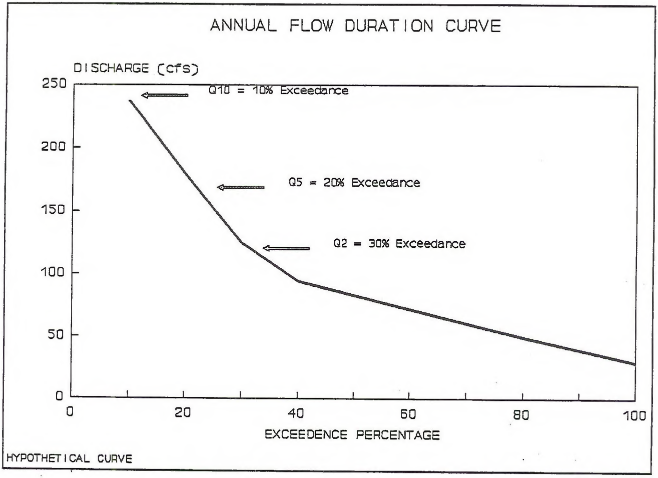


Figure VI-10

Conclusion

USGS expertise will be needed to provide average flow annual hydrographs, frequency of occurrence, and flow duration curves for each VBT being analyzed. Estimates of the frequency and duration of peak flows (Q2, through Q50 and higher) for each VBT will be needed. The USGS has the capability to do this. Once flows are estimated on individual watersheds, then a spreadsheet approach can be used to accumulate flows in a downstream direction. Flows could then be estimated at any location in the two basins. Results of USGS flow simulations and volume estimates need to be verified by matching results with gaged data wherever possible.

The procedures recommended are as follows:

TABLE VI-8. SUMMARY OF RECOMMENDED METHODOLOGY

1. IFIM Flow Analysis	•Establishes minimum instream flow to maintain fish. •Sets late summer/fall flows, usually lower than base flows.
2. VBT Classification	•Segregates stream reaches by section, landtype association, and valley characteristics. •Identifies those stream reaches requiring separate flows for channel, riparian, and valley processes. •Identifies those stream reaches requiring only IFIM-derived flows.
3. HEC-2 Measurements	•Determines extent and elevation of riparian habitat on sampled reach. •Determines elevation of top of bank and terraces in sampled reach. •Calculates discharge (Q) needed to provide bankfull flows and maintain riparian zones and terraces. •Allows quantification of riparian habitat as a function of discharge (a given Q provides some % habitat)
4. Average Annual Hydrograph	•Indicates average discharge, peak flows, and low flows. •Indicates timing of freshet and rates of rising and falling limbs. •Used to calculate daily drawdown rate from recommended flows as of previous day's flow.
5. Frequency of Occurrence Curve	•Indicates return period for flows identified by HEC-2. •Verifies that riparian and valley flow recommendations occur in time because these flows may exceed the average annual hydrograph. •Used in negotiations to show tradeoffs (Q5 recommendation negotiated to Q3 equates to some % loss in riparian habitat).

(Cont'd)

6. Flow Duration Curve	•Demonstrates flow recommended compared to exceedence values (Q25 may occur 4% of the time, Q2 may occur 50% of the time, etc.). •Exceedence converted to time (days) addresses hydrostatic requirements (i.e., flooding duration needed for seeding and germination).
7. Curve Normalization	•Analysis of variance to normalize recommended flows on measured reaches allows extrapolation of fish, channel, riparian, and valley flows to other reaches in the strata.

GIS MAPPING

Maps are already available that compile climatic, geologic, geomorphic, hydrologic, and biotic characteristics. These types of maps or related maps, are already available at the higher levels of resolution (Bailey 1976, Fenneman 1946), at the mid levels of resolution (Wertz and Arnold 1972), and at lower levels (Platts et al. 1988). Lower level mapping is seldom available and must be acquired.

Ecoregion type maps (classification) are useful in narrowing down the area of uniformity. Information can be gained by providing a geographical framework for identifying similar Valley Bottom Types where similar flow responses may be expected. This facilitates a regional rather than site-by-site approach to determining flow patterns and rates.

The rationale behind the overlay mapping technique is that significant ecological response units can be captured by synthesizing or integrating available factor maps. The implicit assumption is that the derived units reflect differences in potential response to management and resource productivity. The strength of a qualitative approach is that all available data can then come under the analysis and expertise of managers, scientists, and planners.

A qualitative approach based on classification encourages selection of the most appropriate array of Valley Bottom Types to assess patterns. To make a flow analysis project successful, classification, data collecting, GIS (General Integration Systems) application, and the final mapping must all be integrated and function together. When this is done the need for inventories and analysis is greatly reduced.

Mapping procedures need to be used that will allow sufficient time to examine a large number of photographs over both space and time. An area encompassing the size of the Salmon and Clearwater River drainages, for example, requires a lot of map and photo interpretation work. In some areas there will be low elevation color infrared and natural color aerial photographs that can be interpreted using a Wild ST-4 stereoscope. If these types of photographs are available, then such variables as water surface area, channel widths, stream lengths, back-channel area, ponded water, non-flowing channels, vegetation habitat type, and vegetation encroachment or erosion can be measured with instruments.

Mapping is used to identify and locate all components necessary to type the Valley Bottom Types. Thus, those types that function similarly and differently are identified. The key to the mapping is that managers can then locate and place themselves within the context of the complete watershed. This allows a better examination of casual effects.

Mapping done at different scales can be rectified with GIS computer software systems for the necessary overlaying for interpretations. However, this is extremely difficult and not recommended. At the finite level, map units are generally ground-truthed by step transects through delineations. Low level aerial maps have scale recording devices located on the maps at key intervals. Through analysis of these small-scale photos distinct patterns of homogeneity and differences can be identified and explained at the Valley Bottom Type level. The use of digital image processing may also help better identify Valley Bottom Types. For mapping to be useful it must be integrated into a computer sensible format so it is more easily handled.

PHOTO INTERPRETATION

Interpreting different types and scales of photographs from elevated vantage points may be the best method available for determining and selling recommended flows. In areas without a good data base and no way to extrapolate surrounding data to it, this may be the only method available. Photography still plays a major role in providing the base for the other interpretation methodologies.

Information collected on the ground can be accelerated and enhanced by the use of large-scale infrared or natural color aerial photography. Canopy, ground cover, bare soil, and floodplains can be delineated. Riparian plant communities can be mapped on large-scale photos. Color photography is usually best for evaluating streambank conditions and bottom types, while color infrared is best for assessing riparian and aquatic vegetation. Little large scale photo coverage (1:2400 to 1:3,00) is available for the Salmon-Clearwater drainages. What information is gleaned from aerial photography must compatible with a lower scale of resolution.

Measurements valuable in flow analysis, especially at the valley maintenance level, are valley width; valley profile, both longitudinal and horizontal; amount of channel surface; channel and gradient profile; and historic interpretation of past flow influences. The historic interpretation is integrated into historic flow data analysis obtained from USGS flow records. The photo interpretation is then integrated into the Valley Bottom Type classification to better define change and response. Historic interpretation or reaction to low flow conditions is then matched with the present condition to predict the future flow needed. On streams regulated in the past those areas that water has not been allowed to penetrate for a long period of time can be evaluated to record the changes that have taken place.

The photographic interpretation is done at four spatial levels, which are integrated to gain a basin perspective:

1. The valley floor above extreme flood flows;
2. The area above average high-water flows to the level of major flood events;
3. The area below average high-water flow to the low-flow condition;
4. The area covered by low base flow.

VEGETATION

Vegetation Use

Vegetation in the riparian ecosystem includes vegetation on a streambank and on a floodplain that has some control over streamside conditions. Riparian vegetation helps to stabilize the streambanks, control nutrient cycling, reduce water velocity, provide cover and food for fish, and intercept and store energy from solar radiation. Riparian vegetation controlling the sunlight reaching the stream limits the energy base for photosynthesis.

Ocular Method

Vegetative use under a transect line and within 5 feet of the shoreline or the top of the streambank, whichever is larger, can be related visually. This evaluation of use includes vegetation disturbed (grazed and trampled) during the present growing season, and potential plant growth that does not exist because of past disturbances of vegetation. An example of loss because of past use would be in areas where vegetation no longer exists because the streambank was dredged or trampled, or where vegetation was eliminated on a major cattle crossing. The rating, however, applies mainly to recent vegetative use. If use is rated only on one occasion or only once a year, it should be done as soon as possible after forage harvesting ceases and before plant regrowth can occur.

The vegetative use rating (this mainly applies to herbaceous vegetation) is stratified into four classes:

Table VI-9. Vegetative Use Rating

Rating (percent)	Description
0 to 25 - (light)	Vegetative use is light or nonexistent. Almost all the potential plant biomass at present stage of development remains. The vegetative cover is close to that which would occur naturally without use. If bare areas exist (such as bedrock) they are not a result of loss of vegetation from land use.
26 to 50 - (medium)	Vegetative use is moderate and at least half of the potential plant biomass remains. Average plant stubble height is greater than half of its potential height at its present stage of development. Plant biomass no longer on site because of past grazing is considered as vegetation that has been used.
51 to 75 - (high)	Vegetation use is high and less than half of the potential plant biomass remains. Plant stubble height is usually over 2 inches (on many ranges). Plant biomass no longer on site because of past grazing is considered vegetation that has been used.
76 to 100 - (extreme)	Use of the streamside vegetation is high and only short stubble remains (usually less than 2 inches on many ranges). Almost all the potential vegetative biomass has been used. Only the root system and part of the stem remain. The potential plant biomass that no longer exists because of use is considered as vegetation that has been used.

Once the observer has decided the class (light to extreme), then the actual percentage of use is determined. For example if the vegetation (grasses and forbs) has been reduced to less than a quarter of potential (usually 2 inches stubble standing height on many ranges), the class rating is between 76 and 100 percent. If the vegetation is removed to almost ground level, the final intra-class rating would be 100 percent. If the vegetation is slightly less than a quarter (usually less than 2 inches stubble height) of its potential and there are no areas without vegetation use, then the intra-class rating would be about 76 percent.

Electronic Meter Methods

Instrument Design and Limitations

The principle behind electronic capacitance metering of vegetation (Neal and Neal 1973) is based on the high dielectric constant of moisture contained in the vegetation relative to the low dielectric constant of the meter's sensing unit. Two parallel oscillators are initially set to the same frequency relative to a no-yield (zero vegetative weight) reference. When vegetation is subsequently introduced to the meter's sensing field, one oscillator is shifted in frequency by an amount proportional to the weight of the vegetation. The meter displays this frequency shift as a dimensionless number that is used to determine corresponding vegetative weights through regression analysis. It is therefore necessary to keep extraneous electrical conductors (such as basalt rock or metal stakes) away from the meter when measurements are being taken.

Capacitance measurements can be taken with the machine at any angle, but the user must remain clear of the sensing field during measurement. Vegetation that fits easily within the meter's probe array is most conveniently measured but taller vegetation can be measured by folding upper projections into probe array. Care should be taken to include only vegetation that is taller in this manner, and to not include vegetation that extends laterally out of the meter's field.

Field Methods

Streamside herbage data are quickly and easily collected, and little training of field personnel is required. To set up a study or monitoring program with the herbage meter, the first step is to select the sites to be compared. These may consist of sites for which standing phytomass in each is to be compared directly; paired sites in which one is ungrazed to determine potential production for comparison with a similar but grazed site for estimating harvest by livestock; a grazed site used in conjunction with ungrazed utilization cages in which potential production can be estimated; or a streambank pasture where increases in productivity resulting from rehabilitative plantings need to be monitored. Whatever the combination of study sites selected, two sets of data must be collected: a large primary data set, which is measured by the meter for capacity only, and a smaller secondary data set that is both metered and clipped and weighed to determine the regression relationship of vegetative weights on capacitance readings. The secondary sample can be either a sub-sample of the primary set, or an independent sample of vegetation like that of the primary set, depending on whether nondestructive sampling of the primary sample is required. If riparian or stream cross-section markers are used, the coordinants of permanent sample plots can be easily established by aligning the center line of the long axis of the meter along the transect line. The location can be permanently referenced by designating a distance away from the stake and the stream with a negative (-) sign and between the stake and the stream with a positive (+) sign (See fig. 6 in Platts et al. 1987). Capacitance of the plot is determined by taking the average of the three readings, or by taking only two readings if the investigator's body is within 2 ft. of the machine during the measurement. Enough time elapses after pushing the "read" button before actual measuring begins for the investigator to step back.

The secondary data can be a sub-sample of the primary set, or an independent set. In the former case, if the selection of secondary plots is accomplished randomly or systematically, the vegetation sampled in the secondary sample will be representative of that in the primary sample. If the secondary data set is an independent sample, care must be taken to assure that it is representative of the vegetation in the primary samples. There should be at least one secondary sample plot for every 5 primary plots (Currie et al. 1973; Neal et al. 1976), though we recommend a ratio of 1:4 to help ensure development of an adequate regression relationship in the heterogeneous riparian area.

Vegetation within the sensing field of the meter is marked off by positioning a 1 by 2 ft. frame around the sampled plot, being careful to remove tall vegetation that extends beyond the meter's field, clipped according to the three-dimensional technique of Currie and others (1973) and weighed in either grams or ounces.

Because annual forage production is of principal concern, grasses and forbs within the frame are clipped on a plane (ignoring ground contour) to a 0.5 inch stubble height; litter should be ignored. For shrubby species only new growth should be removed and included in the weighing sample, because dead wood in the sample plot has little capacitance and would only distort the regression relationship if weighed (Carpenter and others 1973).

Other Habitat Measurements

Several other riparian habitat measurements are also routinely collected. These variables provide additional information about the character of the vegetation being sampled and allow instantaneous comparison of site-specific (primary) and calibration (secondary) samples. The variables also provide evaluations of the trends within the sites over time. The variables are measured concurrently with the taking of capacitance readings and include coverage, vegetative composition and shortest distance to stream.

Cover

This is a measure of the actual proportion within an individual sample plot that is covered by actively growing vegetation. This is a surface area measurement and is visually estimated within the meter's probe array. The probes of the herbage meter form squares, each defining approximately 10 percent of the sample plot (See fig. 7 in Platts et al. 1987). Using these 10 microplots as guides, the percentage of covered and exposed ground within the sample plot can be estimated. When averaged over the entire sample, the percentage of covered and exposed ground within each study site can be estimated.

Species Composition

This measurement evaluates the relative amounts of shrubby and herbaceous species. By imagining individual rectangular volumes for each of the spaces defined by the probes (See fig. 8 in Platts et al. 1987), we can estimate the volumetric proportion, which totals 100 percent, that each type of vegetation contributes to the biomass of the sample plot.

Distance to Stream

While not intended to be a precisely measured factor, the variable does allow a gross evaluation of the average location of sample plots in each site and in the calibration sample with respect to the nearest stream-derived water. It will also allow some early indications of streambank erosion.

Regression Analyses

Regression analyses with capacitance meters have traditionally been conducted using a linear regression model, and good results have been obtained on planted ranges (Currie and others 1973), native herbaceous vegetation (Neal and others 1976) native shrub ranges (Morris and others 1976), and riparian vegetation (Platts and Nelson 1983).

Vegetative Overhang

Vegetative overhang indirectly provides fish food, directly provides cover, and shades the water from solar radiation. Overhang is a valuable variable to use when evaluating land use effects, such as livestock grazing, logging and road construction, that have altered or could alter the riparian habitat. Vegetative overhang rates only that vegetation overhanging the water column. This is a direct measurement to the nearest 0.1 ft. of the vegetation (excluding tree trunks or downed logs) within 12 inches (vertical) of the water surface and overhanging the water column (Figure VI-11). The part of the canopy higher than 12 inches enters the evaluation through the canopy closure and density and solar integrator methods. The vegetative overhang is measured along a transect line,

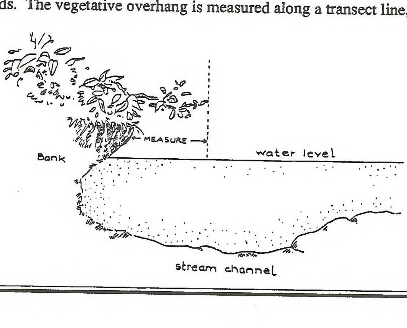


Figure VI-11

beginning at the farthest protrusion of the streambank over the water surface, to the farthest point that vegetation covers the water column. This measurement does not include the undercut. Therefore, bank undercut and vegetative overhang combined give the total immediate overhead cover, excluding other types of cover (such as water surface turbulence).

Table VI-10. Streambank stability rating

Rating	Percent	Description
4	75-100	Over 75 percent of the streambank surface is covered by vegetation in vigorous condition or by boulders and rubble. If the streambank is not covered by vegetation, it is protected by material that does not allow bank erosion.
3	50-74	Between 50 and 74 percent of the streambank is covered by vegetation or by gravel or larger material. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
2	25-49	Between 25 and 49 percent of the streambank surface is covered by vegetation or by gravel or larger material. The area not covered by vegetation is covered by materials that give limited protection.
1	0-24	Less than 25 percent of the streambank surface is covered by vegetation or by gravel or larger materials. That area not covered by vegetation provides little or no control over erosion and the banks are usually eroded each year by high water flows.

INVENTORY AND MONITORING SECTION DEFINITIONS

Active Channel - The channel cross-section at the stage corresponding to bankfull discharge.

Associations - Map units composed of two or more dominant taxa, which could be delineated separately at the scale of mapping that are expected to respond similarly to management applications and inclusion of contrasting taxa.

Alluvial Surfaces - Similar to fluvial surfaces except these surfaces were built some time ago by a stream flowing at a higher elevation.

Bankfull - A totally full channel.

Bankfull Discharge - The flow which just fills the channel to the top of the banks.

Baseflow - The sustained or fair-weather runoff, composed of groundwater runoff and delayed subsurface runoff. Baseflow is often thought of as just that flow that fills the thalweg channel.

Basin - A watershed subset to a subregion or watersheds draining to a particular sink.

Channel - The area between the streambanks. For a graded channel, the area containing moderate to high flow; includes the stream, stream-bars and vertical aspects of the upper banks. Substrates are usually similar to the stream bottom and demonstrate little soil development other than stratification. In some usage it includes the water column, streambanks, channel and instream and streamside vegetation unless each component is identified and discussed separately.

Channel Capacity - The position of water stage (i.e., surface water elevation) in the channel at various discharges.

Channel Confined - The water flow is completely confined within the channel, it does not flow onto a floodplain at high water. A channel without visible signs of a floodplain or one where artificial barriers prevent overflow.

Channel Maintenance Flows - A range and duration of in-channel flows necessary to maintain the stability and effective function of the stream channel. This includes those flows which are necessary to provide for the self-maintenance of the stream channel network so as to retain its capability for passing flood discharges, minimizing channel erosion and/or sediment deposition associated with instability or disequilibrium conditions.

Ecological Land Classification - An ordering of land units based on climatic criteria (macroclimate and microclimate) that combines the elements of landforms, soils, and vegetation into one integrated unit. Until this is achieved, no land classification can be called natural (Daubenmire 1956).

Ecological Integrity - The ability of an ecosystem to sustain a balanced biotic community. The natural environmental characteristics of the ecosystem determine the natural potential integrity.

Ecoregion - Regions of relative homogeneity in ecological systems or in ecological systems or in relationships between organisms and their environments.

Ecosystem - A system resulting from the integration of all living and nonliving factors of the environment. An extension of this definition could imply that ecosystems are productivity systems in which environment comprises the total physical, chemical, and biological surroundings of an organism including habitat.

Ecosystem Resiliency - The property of an ecosystem that allows the system to absorb and utilize (or even benefit from) change.

Environmental Land Systems - Synonymous with ecosystems because they respond to and function in response to the same geoclimatic factors.

Floodplain - That part of the stream channel used to pass high flows. The alluvial surface adjacent to a channel that is frequently inundated.

Flow Duration Curve - A graphical plotting of magnitudes of stream discharge (ordinate axis) against the percent of time each magnitude is equaled or exceeded (abscissa axis).

Flushing Flows - Flows released in regulated streams to simulate high run-off events.

Fluvial Surfaces - The various land surfaces in riparian landforms such as active floodplains, terraces, channel shelves, streambanks, and overflow channels.

Geomorphic Unit - Portions of geologic units that are of similar geomorphic structure and composition.

Herbaceous Community Type - Forbs, grasses, moss and lichen cover greater than 60 percent of the ground surface and herbaceous vegetation is dominant; woody vegetation covers less than 40 percent of the ground surface.

Hydrographic Unit - Watershed drained by a named stream or group of streams.

Land - All terrestrial material above sea level (including Death valley) and including all water, lakes, and streams flowing from or across these lands.

Landscape - An aggregate of landforms, together with its biological communities.

Landtype - Identified based on the principal geomorphic process (i.e., erosion or deposition) characterizing landforms. Usually mapped using 1:24,000 to 1:60,000 scale.

Landtype Association - Identified based on the principal geomorphic mechanism (i.e., glacial, fluvial, alluvial, or lacustrine) apparent in landscapes. Usually mapped on 1:60,000 to 1:125,000 scale.

Landtype Phase - Interchangeable with Valley Bottom Type and identified based on differences in potential streambank communities, soil types, and valley form.

Levee - A feature that forms adjacent to the stream channel that restricts the lateral distribution of high flow.

Macro-Habitat - A habitat description that covers many individual components of the habitat at one time. Stream order, stream size, riverine-riparian habitat type, would be descriptive terms that include many variables such as depth, width, velocity, etc.

Micro-Habitat - Those physical variables which define the precise location occupied by a fish and which would or could change with small changes in fish's location. Those physical variables used by fish to select their location.

Moraine - A mound or ridge of unstratified glacial drift, chiefly till, deposited by the direct action of glaciers. Generally a remnant of glacial retreat and restricted to the lateral extent of floodplains in glacial landtype associations.

Ordination - A set of statistical techniques that arranges sites or environmental variables (chemical, physical, or biological) in relation to one or more coordinate axes such that their positions relative to the axes and to each other provide maximum information about their ecological similarities.

Permanently Flooded - Water covers the surface throughout the growing season; the depth of water is less than that which restricts the establishment of wetland vegetation.

Physiography - The study of the three major physical divisions of the globe: land (geomorphology), atmosphere (meteorology and climatology), and oceans (oceanography) (Lobeck 1939). Pertains to the genesis, structure, and evolution of landforms.

Physiographic Section - A subset of a physiographic province used to identify areas with a more discrete range in geologic structure and climate (Fenneman 1931). Usually mapped at a 1:500,000 to 1:1,000,000 scale.

Physiographic Subsection - A subset of a physiographic section used to identify areas with still more discrete range in geologic structure and climate (Fenneman 1931). Usually mapped at a 1:250,000 to 1:500,000 scale.

Reference Sites - Areas (watersheds, stream reaches, lakes, etc.) where environmental characteristics are representative of other areas and where measured data values are inferred to indicate those of other areas.

Region - An area of relative homogeneity for a particular set of characteristics. The watershed of the highest order streams draining to the ocean or other sinks in watersheds lacking external drainage to the sea. Usually mapped at a 1:1,000,000 to 1:3,000,000 scale.

Regionalization - A method of reducing or eliminating details which do not, on the average, hold true over large areas.

Relief - An index of the potential energy available in a drainage basin measured by the difference in elevation between specified points of a landscape.

Riparian Ecosystem - Land and vegetation transitional between aquatic and upland that is characterized by hydric soil and hydrophilic vegetation.

Riverine Ecosystem - Land, vegetation and water contained within a stream system. Includes stream-bars and the stream bottom. The substrates are fluvial sediments with a low degree of soil development.

Riverine-Riparian Ecosystem - The union of riverine and riparian components. For a given watershed there is usually a single ecosystem usually bordering the waterway.

Riverine-Riparian Habitat - Some functional subset of a riverine-riparian ecosystem that includes areas of similar natural state.

Riverine-Riparian Types - Some functional subset of riverine-riparian habitat that includes areas of similar existing state.

Rock Type - Areas of similar surficial mineral composition that weather to form sediments of distinctive size-fractions and mineral composition under similar climates. Usually mapped at a 1:24,000 to 1:250,000 scale.

Seasonally Flooded - The surface is flooded for extended periods during spring runoff of most years, but surfaces are dry by the end of most growing seasons. Flooding is commonly associated with floodplains and channel levees.

Semi-Permanently Flooded - Water covers the surface throughout most of the growing season.

Spatial Distribution - The areal arrangement of attributes (e.g., environmental characteristics, data values, species, land use types, etc.).

State - A set of conditions a stream attains over time in response to external and in-stream controls.

Streamflow Duration - The flow regimen describing the basic behavior of seasonal flows. Rosgen (1985) describes flow regimen as ephemeral, subterranean, intermittent, and perennial.

Streamflow Regulation - An additional modifier to stream variation for categorizing the largest influence on flow. Examples would be reservoir, spring-fed, or groundwater control.

Streamflow Variation - A description of the change in stage. Quantitative description can be made using average runoff volume, peak flow, time of peak flow, and nature of peak flow.

Trophic State - The intensity of primary productivity in a stream, often estimated by the nutrient (nitrogen and phosphorus) enrichment to the water body.

Valley - Includes all soils, vegetation, channel, and water within the valley floor.

Valley Bottom - Refers to stream channels, floodplains, and land immediately adjacent to hillslope and entrenched channels.

Valley Bottom Morphology - The landform shape adjacent to streams and the degree of entrenchment of channels within landforms. Determinants used are often valley bottom width, side hill slope angle, and channel entrenchment.

Water Regime - Areas distinguished by the frequency and duration of flooding, the dynamics of alluvial groundwater, and/or saturation by spring discharge.

Watershed - A drainage basin that gathers water from precipitation and delivers it to a larger watershed. Watershed is dimensionless and depends on the area you need in the analysis. It could be a first order stream or all the basins composing a 6th order

REFERENCES

Acocks, J. P. 1966. Non-selective grazing as a means of veld reclamation. Proceedings of the Grassland Society of the Southwest.

Ames, C. 1977. Wildlife conflicts in riparian management: grazing. *In* A Symposium on the Importance, Preservation, and Management of Riparian Habitat. Gen. Tech. Rpt. RM-43. Rocky Mtn. Forest and Range Exp. Sta., USFS, Ft. Collins, CO. pp.49-51.

Andrews, E. D. 1986. Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah. Geol. Soc. of America Bulletin.

Annear, T. C., and A. I. Conder. 1984. Relative bias of several fisheries' instream flow methods. North American Journal of Fisheries Management. 4:531-539.

Armour, Carl L. 1977. How the National Environmental Policy Act (NEPA) can be thwarted-possible corrective measures. Fisheries 2(4):14-17.

Armour C. L. et al. 1983. Field methods and statistical analysis for monitoring small salmonid streams. FWS/OBS-83/33. U.S. Fish and Wildlife Service, Washington, D.C.

Arnold, J. F. 1975. Descriptions of sections and subsections ofthat portion of the Northern Rocky Mountain Physiographic Province containing the Idaho Batholith. USDA Forest Service, Intermountain Region, Ogden, UT. 342p.

Bailey, R. G. 1976. Ecoregions of the United States. Map with descriptions. USDA Forest Service, Intermountain Region, Ogden, UT.

Bailey, R. G. 1978. Description of ecoregions of the United States. USDA Forest Service, Intermountain Region, Ogden, UT.

Bailey, R. G. 1983. Delineation of ecosystem regions. Environmental Management 7:365-373.

Bailey, R. G. 1983. Description of ecoregions of the United States. USDA Forest Service. Intermountain Region, Ogden, UT.

Bartholow, J. M. 1987. Stream Segment Temperature Models, Aquatic Systems Branch, U.S. Fish and Wildlife Service. Fort Collins, CO. Program and documentation for microcomputers. (On disk.)

Bartholow, J. M. 1989. Applied stream temperature analysis: field and analytic methods. Instream Flow Inf. Pap. 13. Aquatic Systems Branch. Biol. Rep. 89(17). 139 pp.

Behnke, R. J., Mark Zarn. 1976. Biology and management of threatened and endangered western trouts. USDA Forest Service, Gen. Tech. Rep. RM-28; Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO.

Bell, M. C. 1984. Fisheries handbook of engineering requirements and biological criteria. Corps of Engineers, Fish Passage Development and Evaluation Program, Portland, OR. 575p.

Bergstrom, Dorothy. 1985. Beavers: biologists "rediscover" a natural resource. Forest Research West, October. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

Beschta, Robert and W. J. Jackson. 1979. The intrusion of fine sediments into a stable gravel bed. J. Fish. Res. Bd. Can. 36(2): 204-210.

Beschta, R. L. 1983. Long-term change in channel widths of the Kowai River, Torlesse Range, New Zealand, Journal of Hydrology 22(2):112-122.

Beschta, R. L., and W. S. Platts. 1986. Morphological features of small streams: Significance and function. Water Resources Bulletin 22(3):369-379.

Bisson, P. A., J. L. Nielson, R. A. Palmason, and L. E. Grove. 1982. A system of naming habitat types in small streams with examples of habitat utilization by salmonids during low stream flow. *IN* N. B. Armantrout, (ed.) Acquisition and utilization of aquatic habitat inventory information. Pp. 62-73. Proceedings of symposium held Oct. 28-30, 1981, Portland, Oregon. Western Division, American Fisheries Society.

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. H. Milligan, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Completion Report, Water Resources Research Institute, Project B-036-IDA, University of Idaho, Forest, Wildlife, and Range Experiment Station, Moscow, ID. 43p.

BLM (USDI Bureau of Land Management). 1974. Effects of livestock grazing on wildlife, watershed, recreation and other resource values in Nevada. BLM Evaluation Report, Washington, DC.

BLM (USDI Bureau of Land Management.) 1986. Draft BLM riparian area management policy. Paper presented at BLM Riparian Management Workshop. June 3-4, 1986. Helena, MT. 4 pp.

Bovee, K. 1982. A guide to stream habitat analysis using the instream flow incremental meth odology. Instream flow information paper No. 12. U.S. Fish and Wildlife Service. FWS/OBS-82/26.

Boyd, C. 1979. Water Quality Criteria in Warmwater Fish Ponds. Auburn Univ. Press, AL. 358p.

Branford, J., D. Farrell and W. Larson. 1973. Mathematical evaluation of factors affecting gully stability. Soil Sci. Amer. Proc.37:103-7.

Branford, J. and R. Piest. 1977. Gully wall stability in loess-derived alluvium. Soil Sci. Soc. Amer. Journal 41:115-122.

Braun, Richard H. 1986. Emerging limits on federal land management discretion: livestock, riparian ecosystems, and clean water law. Environmental Law 17: 43-79.

Brown, D. E., and C. H. Lowe. 1974. A digitized computer-compatible classification for natural and potential vegetation in the Southwest with particular reference to Arizona. *In* Biotic Communities of the American Southwest-United States and Mexico. Desert Plants, 4(1-4), University of Arizona Press, Tucson.

Bryant, L. D. 1979. Livestock management in the riparian ecosystems. Pages 285-289. *In* Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. Proceedings of the Symposium. USDA Forest Service, General Technical Report RM-120. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Burkham, D. E. 1976. Hydraulic effects of changes in bottom-land vegetation on three major floods, Gila River in southeastern Arizona. U.S. Geol. Surv. Prof. Paper 655-J. p.J1-J14.

Burns, D. C. 1984. An inventory of embeddedness of salmonid habitat in the South Fork Salmon River drainage, Idaho. Unpublished Report, USDA Forest Service, Payette and Boise National Forests, Boise and McCall, ID. 30p.

Burns, D. C., and R. E. Edwards. 1985. Embeddedness of salmonid habitat of selected streamson the Payette National Forest. Unpublished Report, USDA Forest Service, Payette National Forest, McCall, ID.

Busby, F. E., and G. F. Gifford. 1978. Impact of management on watershed values: Pages 192-209 *In* The Sagebrush Ecosystem: A Symposium. Utah State University, College of Natural Resources, Logan, UT.

Carson, M. A. and G. A. Griffiths. 1987. Influence of channel width on bed load transport capacity. ASCE Jour. Hyd. Eng. 113:12 pp. 1489-1509.

Chaney, E., W. Elmore and W. S. Platts. 1990. Livestock grazing on western riparian areas. U.S. Environmental Protection Agency, Denver, Colorado. 45p.

Chapman, D. W., and K. P. McLeod. 1987. Development of criteria for fine sediment in the Northern Rockies ecoregion. Final Report. U.S. Environmental Protection Agency, EPA 910/9-87-162, Seattle, WA. 279p.

Chorley, R. J., S. A. Schumm and D. E. Sugdem. 1984. GEOMORPHOLOGY. Methuen and Company, London, England. 605 p.

Clifton, C. F. 1987. Effects of vegetation and land use of the channel morphology of Wickiup Creek, Blue Mountains, Oregon. Master of Science, Division of Geology, University of Wisconsin, Madison.

Cline, R., G. Cole, W. Megahan, R. Patten, and J. Potyondy. 1981. Guide for predicting sediment yields from forested watersheds. USDA Forest Service, Northern and Intermountain Regions, Missoula, MT, and Ogden, UT. 41p.

Cole, G. F. 1972. Valley types, an extension of the land systemsinventory to valleys. USDA Forest Service, Boise National Forest, Boise, ID.

Collotzi, A. W. 1974. A systematic approach to the stratification of the valley bottom and the relationship to land use planning. pp.484-497 *In*: Instream Flow Needs, Volume 1. American Fisheries Society, Bethesda, MD.

Colt, J. 1984. Computation of dissolved gas concentrations in water as functions of temperature, salinity, and pressure. Am. Fish. Soc. Spec. Pub. No. 14, Bethesda, MD. 154p.

Combs, B.D. 1964. Effect of temperature on the normal development of salmon eggs. Prog. Fish Cult. 27(3):134-137.

Contor, C. R., and W. S. Platts. In preparation. Assessment of COWFISH in estimating trout abundance in several streams in Idaho, Nevada and Utah. USDA Forest Service, Intermountain Research Station, Boise, ID. 62p.

Cooper, H. H., and M. I. Rorabaugh. 1963. Groundwater movements and bank storage due to flood stages in surface streams, U.S. Geological Survey Water Supply Paper 1613-c.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. Laroe. 1979. Classification of wetlands and deep-water habitats of the United States. FWS/OBS 79/81. U.S. Government Printing Office, Washington, D.C.

Daubenmire, R. 1968. Plant communities. Harper and Row, New York, NY.

Davis, G. A. 1977. Management alternatives for the riparian habitat in the Southwest. Pages 59-76. *In* Importance, preservation and management of riparian habitat. USDA Forest Service, General Technical Report RM-43, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Davis, J. C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: A review. J. Fish. Res. Board Can. 32: 2295-2332.

Davis, J. 1982. Livestock and riparian management -- why not? Pages 225-232 *In* Proceedings of the 62 Western Association of Game and Fish Commissioners Meeting. Las Vegas, NV.

Diesch, S. I. 1970. Disease transmission of water-borne organisms of animal origin. *In* T. E. Willrich and G. E. Smith [eds.] Agricultural Practices and Water Quality. Iowa State Univ. Press, Ames. pp.265-285.

Doran, J. W., J. S. Schepers, and N. P. Swanson. 1981. Chemical and bacteriological quality of pasture runoff. J. Soil and Water Cons. 36(3): 166-171.

Dorfman, D. and W. R. Wentworth. 1969. Effects of fluctuations of lead, temperature, and dissolved oxygen on the growth of brook trout. Fish. Res. Board Canada 26(9):2493-2501.

Elmore, W. and R. L. Beschta. 1987. Riparian areas: Perceptions in management. Rangelands 9(65):260-265.

Espinoza, F. A., Jr., R. Patten, and D. Wilson. 1981. Aquatic-ecological land units for the Clearwater National Forest. Unpublished report. USDA Forest Service, Clearwater National Forest, Orofino, ID.

Everest, F. H., R. L. Beschta, J. C. Scrivener, K. V. Koski, J. R. Sedell, and C. J. Cederholm. 1987. Fine sediment and salmonid production: a paradox. pp. 98-142 *In*: E.O. Salo and T.W. Cundy. 1987. Streamside Management: Forestry and Fishery Interactions. College of Forest Resources and Institute of Forest Resources, University of Washington, Seattle, WA.

Everest, F., et al. In Draft. A test of the Rosgen Channel Types. USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR.

Fenneman, N. M. 1931. Physiography of western United States. McGraw Hill Book Company, Inc., New York, NY. 534p.

Fenneman, N. M. 1946. Physical divisions of the United States Map (scale 1:7,500,00). U.S. Department of Interior, Geological Survey. Reston, VA.

Fisher, S. G. 1972. Stream ecosystem: Organic energy budget. Bio. Sci. 22:33-35.

Freeze, R. A. 1972. Role of subsurface flow in generating surface runoff: 1. Baseflow contributions to channel flow. Water Resources Research., 8:1272-1282.

Freeze, R. A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Englewood Cliffs, NJ.

Frissell, C. A., W. J. Liss, C. E. Warren, and M. D. Hurley. 1986. A hierarchical framework for stream habitat classification: Viewing streams in a watershed context. Environmental Management. 10:199-214.

GAO (General Accounting Office). 1988. Public Rangelands: Some riparian areas restored, but widespread improvement will be slow. RFCD-88-10. Washington, DC.

Gifford, G. F., and R. H. Hawkins. 1976. Grazing systems and watershed management: a look at the record. Journal of Soil and Water Conservation 31(6):281-283.

Graf, W. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. Geological Soc. of Amer. Bull. 89:1491-1501.

Gregory, K. J. and C. Park. 1974. Adjustment of river channel capacity downstream from a reservoir. Water Resources Research, Vol. 10, No. 4, pp. 870-873.

Gurnell, A. M. and Gregory, K. L. 1984. The influence of vegetation on stream channel processes. Pages 515-535. *In* Catchment Experiments On Stream Channel Processes. Geo Books, Norwich, U.K.

Hadley, R. 1961. Influence of riparian vegetation on channel shape, northeastern Arizona. U. S. Geol. Surv. Res. 156, p.C30-31.

Hall, J. D., and N. J. Knight. 1981. Natural variation in abundance of salmonid populations in streams and its implications for design of impact studies. Technical Report Paper 5608. Corvallis, OR: Oregon State University, Oregon Agricultural Experiment Station. 85p.

Hammond, E. H. 1970. Classes of land surface form. Maps (scale 1:7,500,000). *In* The National Atlas of the United States of America. U. S. Geological Survey, Washington, D. C. Plates 62-63.

Harvey, M., C. Watson and S. Schumm. 1985. Gully Erosion. BLM Tech. Note 366. Order No. BLM-YA-PT-85-002-4340. 181pp.

Heady, H. F. and others. 1974. Livestock grazing on federal lands in the 11 western states. Journal of Range Management 27(3):174-181.

Heede, B. 1985. Interactions between streamside vegetation and stream dynamics. *In* Symposium,' Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. April 16-18, 1985, Tucson, AZ.

VII-6 **Hendricks, C. W. and S. M. Morrison.** 1967. Multiplication and growth of selected enteric bacteria in clear mountain streamwater. *In* Water Research, Pergamon Press, London.

Hey, R. D. and C. R. Thorne. 1986. Stable channels with mobile gravel-beds. J. Hyd Eng. ASCE.

Hickin, E. 1984. Vegetation and river channel dynamics. Canadian Geographer 28(2):111-126.

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. Summer and winter habitat selection by juvenile chinook salmon in a highly sedimented Idaho stream. Transactions of the American Fisheries Society. 116:185-195.

Hills, A. G. 1976. An Integrated iterative holistic approach to ecosystem classification. Proceedings of the first meeting. Canadian Commission on Ecological (Biophysical) Land Classification. Petawawa, Ontario, Canada.

Holcheck, J. L. 1983. Considerations concerning grazing systems. Rangelands 5(5):208-211.

Hooke, J. M. 1979. An analysis of the processes of bank erosion. Journal of Hydrology 42:39-62.

Howard, Rebecca J. and Joseph S. Larson. 1985. A stream habitat classification system for beaver. J. Wildl. Mgt. 49(1):19-25.

Hughes, R. M., D. P. Larsen, and J. M. Omernik. 1986. Regional reference sites: A method for assessing stream potentials. Environmental Management. 10:629-635.

Hunt, C. B. 1972. Geology of soils: their evolution, classification, and uses. W. J. Freeman and Company, San Francisco, California, USA.

Hynes, H. B. N. 1970. The ecology of running waters. University of Toronto Press, Toronto.

Irving, J. S. and T. C. Bjornn. 1984. Effects of substrate size composition on survival of kokanee salmon and cutthroat and rainbow trout. Idaho Cooperative Fishery Research Unit. Tech. Rep. 84-6: 21p.

Jensen, S., R. Ryel, and W. S. Platts. 1989. Classification of riverine-riparian habitat and assessment of non-point source impacts, North Fork Humboldt River, Nevada. Pilot study review draft on file. USDA Forest Service, Intermountain Research Station, Boise, ID.

Johnson, H. P. and W. C. Moldenhauer. 1970. Pollution by sediment: Sources and the detachment and transport process, p. 3-20. *In* Agriculture Practices and Water Quality. Iowa State Univ. Press, Ames.

Johnson, W. M. 1965. Rotation, rest-rotation, and season long grazing on a mountain range in Wyoming. USDA Forest Service Research Paper RM-14, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

Jones, J. R. Fish and River Pollution. Butterworths Pub., London.

Kauffman, J. Boone, W. C. Krueger, and M. Varva. 1983. Impacts of cattle on streambanks in northern Oregon. Journal of Range Management 36(3): 683-685.

Kauffman, J. Boone, and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications...a review. Journal of Range Management 37(5): 430-438.

Kelley, D. W., and D. H. Dettman. 1980. Relationships between streamflow, rearing habitat, substrate condition, and juvenile steelhead populations in Langunitas Creek, Marine County, 1979. Report prepared for The Marine Municiple WaterDistrict. 23 p.

Klontz, G. W. 1985. Water quality and dissolved oxygen in hatcheries. Tech. Comp. Rep., Idaho Water Resources Research Institute, University of Idaho, Moscow.

Knighton, A. D. 1973. Riverbank erosion in relation to streamflow conditions, River Bollin-Dean, Cheshire, East Midland Geographer 49:416-426.

Koppen, W. 1931. Gundris der Klimakunde. Walter de Gruyter Cp., Berlin, Germany.

Kothmann, M. M. 1974. A glossary of terms used in range management. American Society of Range Management, Portland, Oregon.

Kovalchik, B. L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. USDA Forest Service, Pacific Northwest Region, Ecology Technical Paper 279-87, Portland, OR.

Kraeger-Rovey, C. E., 1975. Numerical model of flow in a stream aquifer system. Colorado State University, Hydrology paper 74, Ft. Collins, CO.

Kunkle, S. H. 1970. Sources and transport of bacterial indicator in rural streams. Symp. on Inter. Aspects of Watershed Mgt. Montana State University, Bozeman, 31p.

Lagler, K. F., J. E. Bardach, and R. R. Miller. 1962. Ichthology. John Wiley and Sons, Inc., New York, NY.

Lanka, R. P., W. A. Hubert, and T. A. Wesche. 1987. Relations of geomorphology to stream habitat and trout standing crop in small Rocky Mountain streams. Transactions of the American Fisheries Society 116:21-28.

Larsen, D. P., J. M. Omernik, R. M. Hughes, C. M. Rohm, T. R. Whittier, A. J. Kinney, A. L. Gallant, and D. R. Dudley. 1986. Correspondence between spatial patterns in fish assemblages in Ohio streams and aquatic ecoregions. Environment Management. 10:615-628.

Larsen, D. P. and D. R. Dudley. In Press. A regional approach for assessing attainable surface water quality: Ohio as a case study. Journal of Soil and Water Management.

Lemmon, P. E. 1956(a). A new instrument for measuring forest overstory density. Journal of Forestry. 55:667-669.

Lemmon, P. E. 1956(b). A spherical densiometer for estimating forest overstory density. Forest Science. 2:314-320.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial Processes in Geomorphology. W. H. Freeman and Company, San Francisco, California.

Leopold, L. and W. Langbein. 1966. River meanders. Scientific Am. 214(6):60-70.

VII-8 **Lloyd, J. R.** 1986. COWFISH habitat capability model. USDA Forest Service, Fish Habitat Relationships Program, P.O. Box 7669, Missoula, MT. 33 p.

Lobeck, A. K. 1939. Geomorphology. McGraw-Hill Book Company, Inc., New York, NY.

Lotspeich, F. B. 1980. Watersheds as the basic ecosystem: this conceptual framework provides a basis for a natural classification system. Water Resources Bulletin 16:581-586.

Lotspeich, F. B. and W. S. Platts. 1982. An integrated land-aquatic classification system. North American Journal of Fisheries Management. 2:138-149.

Lusby, G. C. 1979. Effects of grazing on runoff and sediment yield from desert rangeland at Badger Wash in western Colorado. USDI Geologic Survey Water Supply Paper 1532-I. 34p.

Mack, W. N. 1974. Investigations into occurence of coliform organisms from pristine streams. Dep. Microbio. and Pub. Health, Michigan State University., East Lansing, 18p.

Maddock, T. Jr. 1972. Hydraulic behavior of stream channels. Trans. of the Thirty-seventh North American Wildlife and Natural Resources Conf. p. 366-374.

Marlow, C. B., and T. M. Pagacnik. 1986. Cattle feeding and resting patterns in foothills riparian zone. Journal of Range Management. 39(3): 212-216.

Mathur, D., W. H. Bason, E. J. Purdy and C. A. Silver. 1985. A critique of the instream flow incremental methodology. Canadian Journal Fisheries Science. 42:825-831.

McCuddin, M. E. 1977. Survival of salmon and trout embryos and fry in gravel-sand mixtures. Thesis presented in partial fulfillment of M.S. degree, University of Idaho, Moscow.

Meehan, W. R., and W. S. Platts. 1978. Livestock grazing and aquatic environment. Journal of Soil and Water Conservation 33(6):274-278.

Meyer, Phillip. 1982. A critique of the report " Fish, energy andthe Columbia River: An economic perspective on fisheries values lost and at risk". Aquabionics.

Minshall, G. W., K. W. Cummins, T. L. Bott, J. R. Sedell, C. E. Cushing, and R. L. Vannote. 1983. Developments in stream ecosystem theory. Canadian Journal Fisheries and Aquatic Science. 42:1045-1055.

Minshall, G. W., R. C. Petersen, K. W. Cummins, T. C. Bott, J. R. Sedell, and C. E. Cushing. 1983. Interbiome comparison of stream ecosystem dynamics. Ecological Monographs 51:1-25.

Morisawa, M. 1968. Streams: Their dynamics and morphology. McGraw-Hill Book Co. New York, NY. 175pp.

Morris, M. J., K. L. Johnson, and D. L. Neal. 1976. Sampling shrub ranges with a electronic capacitance instrument. Journal of Range Management 29(1): 78-81.

Myers, L. 1981. Grazing on stream riparian habitats in southwestern Montana. Proceedings of the Montana Chapter, Wildlife Society, Great Falls, MT.

Neal, D. L., and J. L. Neal. 1973. Uses and capabilities of electronic capacitance instruments for estimating standing herbage. Part 1. History and development. Journal of the British Grassland Society. 28:81-89.

Neal, D. L., P. Currie, P. O. Morris, and J. Meredith. 1976. Sampling herbaceous native vegetation with an electronic capacitance instrument. Journal of Range Management 29(1): 74-77.

Nelson, R. L., W. S. Platts, Sherman E. Jensen, and D. P. Larson. In Preparation. Distribution and abundance of native and introduced trout in relation to geology and geomorphology in the North Fork Humboldt River drainage, Northeastern Nevada. Draft On File. USDA Forest Service, Intermountain Research Station, Boise, ID.

Omernik, J. M. and A. L. Gallant. 1986. Ecoregions of the Pacific Northwest, United States Environmental Protection Agency, EPA/600/3-86/033, Corvallis, OR.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118-125 and map (scale 1:7,500,000).

Park, C. C. 1977. Man induced changes in stream channel capacity. *In* River Channel Changes. K. J. Gregory (ed.), J. Wiley and sons, New York, NY. jpp. 121-144.

Peterson, R. 1983. Riparian area management on the national forest system. Fisheries 8(6): 22-25.

Piper, R., I. McElwain, L. Orme, J. Caren, L. Fowler, and J. Leonard. 1982. Fish Hatchery Management. USDI, Fish & Wildlife Service, Washington, D.C. 516p.

Platou, K. A., and P. T. Tueller. 1985. Evolutionary implications for grazing management systems. Rangelands 7(2): 57-61.

Platts, W. S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification - with application to ecosystem management. USDA Forest Service, Intermountain Region SEAM Program, Ogden, UT.

Platts, W. S. 1978. Livestock interaction with fish and aquatic environments: Problems in evaluation. *In* Trans., 43rd N. Am. Wildlife and Nat. Res. Conf. Wildlife Management Institute, Washington, D.C. pp. 498-504.

Platts, W. S. 1979. Including the fishery system in land planning, USDA Forest Service General Technical Report INT-60. Intermountain Forest and Range Experiment Station, Ogden, UT.

Platts, W. S. 1979. Relationships among stream order, fish populations, and aquatic geomorphology in an Idaho river drainage. Fisheries. 4(2):5-9.

Platts, W. S. 1980. A plea for fishery classification. Fisheries. 5(1):2-6.

Platts, W. S. 1981. Sheep and cattle grazing strategies in riparian-stream environments. Pages 82-92 *in* Proceedings, wildlife-livestock relationships symposium. University of Idaho Forest and Range Experiment Station, Moscow.

VII-10 **Platts, W. S., W. F. Megahan, and G. W. Minshall.** 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service, General Technical Report INT-138, Intermountain Forest and Range Experiment Station, Ogden, UT. 70p.

Platts, W. S., R. L. Nelson, O. Casey, and V. Crispin. 1983. Riparian-stream habitat conditions on Tabor Creek, Nevada, under grazed and ungrazed conditions. Pages 162-175 *in* Proceedings of the 63rd Annual Conference of the Western Association of Fish and Wildlife Agencies, Jackson, WY.

Platts, W. S. 1984. Compatibility of livestock grazing strategies with riparian-stream systems. Pages 67-74 *in* Proceedings Pacific Northwest range management short course: range watersheds, riparian zones, and economics: interrelationships in management and use. Oregon State University, Corvallis, OR.

Platts, W. S., and F. J. Wagstaff. 1984. Fencing to control livestock grazing on riparian habitats along streams: is it a viable alternative? North American Journal of Fisheries Management 4:266-272.

Platts, W. S., K. A. Gebhardt, and W. L. Jackson. 1985. The effects of large storm events or basin-range riparian stream habitats. Pages 30-34 *in* North American riparian conference proceedings, Tucson, Arizona, April 16-18, 1985. U.S. Forest Service General Technical Report RM-120, Fort Collins, CO.

Platts, W. S., and R. L. Nelson. 1985. Stream habitat and fisheries response to livestock grazing and instream improvement structures, Big Creek, Utah. Journal of Soil and Water Conservation 49(4):374-379.

Platts, W. S., and R. L. Nelson. 1985a. Impacts of rest-rotation grazing on streambanks in forested watersheds in Idaho. North American Journal of Fisheries Management 5:547-556.

Platts, W. S., and R. L. Nelson. 1985b. Stream habitat and fisheries response to livestock grazing and instream improvement structures, Big Creek, Utah. Journal of Soil and Water Conservation 40(4):374-379.

Platts, W. S., and R. L. Nelson. 1985c. Streamside and upland vegetation use by cattle. Rangelands 7(1):5-10.

Platts, W. S., and R. L. Nelson. 1985d. Will the riparian pasture build good streams? Rangelands 7(4):7-11.

Platts, W. S.; C. Armour; G. Booth; B. Bryant; J. Bufford; P. Cuplin; S. Jensen; G. Lienkalmper; G. Minshall; S. Monsen; R. Nelson; J. Sedell; J. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. USDA Forest Service, Intermountain Research Station, GTR INT-221, Ogden, UT.

Platts, W. S. 1988. Classification of riverine-riparian habitats for management fisheries resources. Progress Report 4. Unpublished report on file, USDA Forest Service, Intermountain Research Station, Boise, ID.

Platts, W. S., S. Jensen, F. Smith. 1988. Preliminary classification and inventory of riverine-riparian habitats and livestock/fishery study areas, Nevada. Nevada Department of Wildlife, Elko.

Platts, W. S., and M. L. McHenry. 1988. Density and biomass of trout and char in western streams. USDA Forest Service, General Technical Report INT-241, Intermountain Research Station, Ogden, UT. 17p.

Platts, W. S. and R. L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management. 8:333-345.

Platts, W. S., and R. L. Nelson. 1989. Stream canopy and its relationship to salmonid biomass in the intermountain west. North American Journal of Fisheries Management. 9(4):446-457.

Platts, W. S., R. Torequemada, M. McHenry and C. Graham. 1989. Changes in salmon spawning and rearing habitat from increased delivery of fine sediment to the South Fork Salmon River, Idaho. Transactions of the American Fisheries Society 118: 274-283.

Platts, W. S., and R. L. Nelson. In preparation. Testing the FISHSED model. USDA Forest Service, Intermountain Research Station, Forestry Sciences Laboratory, Boise, ID.

Rand, G. M. and S. R. Petrocelli. 1985. Fundamentals of Aquatic Toxicology. Hemisphere Pub., Washington, D. C. 666p.

Ray, G. A., and W. F. Megahan. 1978. Measuring cross-section using a sag tape: a generalized procedure. General Technical Report INT-47. USDA Forest Service, Inter mountain Forest and Range Experiment Station, Ogden, UT. 12 p.

Ray. G. A., and W. F. Megahan. 1979. Measuring cross-sections using a sag tape: a generalized procedure. Gen. Tech. Rep. INT-47, USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 12 p.

Reiser, S. W., M. P. Ramey and J. R. Lambert. 1985. Review of flushing flow requirements in regulated streams. Pacific Gas and Electric Company Research and Development Report. San Ramon, CA.

Ringler, N. H. and J. D. Hall. 1975. Effects of logging on water temperature and dissolved oxygen in spawning beds. Trans. Am. Fish. Soc. 104(3):117-121.

Roath, L. R., W. C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. Journal of Range Management 35(1):100-103.

Rosgen, D., and L. Silvey. 1980. Channel types for Region 2. Unpublished report, USDA Forest Service, Ft. Collins, CO.

Rosgen, D. L. 1985. A stream classification system. USDA Forest Service, General Technical Report. Rm-120:91-95.

Rosgen, D. L., H. L. Silvey, J. P. Potyondy. 1986. The use of channel maintenance flow concepts in the Forest Service. Hydrological Science and Technology, American Institute of Hydrology, Minneapolis, MN. 2:19-26.

Savory, C. A. 1978. A holistic approach to range management using short duration grazing. *In* Proceedings of the First International Rangeland Congress. 1:555-557.

Savory A., and S. Parsons. 1980. The Savory grazing method. Rangelands 2(6):234-237.

VII-12 **Schumm, S. 1960.** The shape of alluvial channels in relation to sediment type. U.S. Geol. Surv. Prof. Paper 352-B, pp.17-30.

Schumm, S. and R. Lichty. 1963. Channel widening and floodplain construction along Cimarron River in southwestern Kansas. U.S. Geol. Surv. Prof. Paper 352-D. pp. 71-88.

Shepard, B. 1989. Evaluation of the U. S. Forest Service "COWFISH" model for assessing livestock impacts on the fisheries in the Beaverhead National Forest. pp 23-33. *In* R. Gresswell, B. Barton, and J. Kershner editors. Proceedings of the Riparian Resource Management: and Educational Workshop. Billings, Montana. May 8-11. Printed by USDI Bureau of Land Management, Billings. 193 p.

Skinner, Q. D., J. C. Adams, and P. A. Richard. 1972. Influence of summer use of a mountain watershed on bacterial water quality. *In* Age of Changing Priorities for Land and Water. Irrigation and Drainage Div. Specialty Conf., Spokane, WA., Pub. by ASCE.

Skovlin, J. M. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. *In* Developing Strategies for Rangeland Management --- A Report Prepared By the Committee On Developing Strategies For Rangeland Management. National Research Council and National Academy of Sciences. Western Press Inc., Boulder CO, 102p.

Smith, D. G. 1976. Effect of vegetation on lateral migration of anastomosed channels of a glacier meltwater river. Geological Soc. of Amer. Bull. 87:857-860, Doc No. 60604.

Steger, R. E. 1982. Rapid rotation grazing programs in Texas Rangelands 4(2):75-77.

Stowell, R., A. Espinoza, T. C. Bjornn, W. S. Platts, D. C. Burns, and J. S. Irving. 1983. Guide for predicting salmonid response to sediment yields in Idaho Batholith watersheds. USDA Forest Service, Northern and Intermountain Regions, Missoula, MT, and Ogden, UT. 95p.

Strahler, A. N. 1964. Quantitative geomorphology of drainage basins and channel networks. *In* Chow, V. T., editor. Handbook of applied hydrology—a compendium of water research technology, Section 4:39-76. McGraw-Hill Book Company, New York, NY.

Strickler, G. S. 1959. Use of the densiometer to estimate density of forest canopy on permanent sampling plots. Research note no. 180, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Stumm, W. and J. J. Morgan. 1970. Aquatic Chemistry. John Wiley and Sons, Inc., New York, NY. 583p.

Swales, S., R. B. Lauzier, and C. D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. Canadian Journal of Zoology. 64:1506-1514.

Tansley, A. G. 1935. The use and abuse of vegetational concepts and terms. Ecology 16:284-307.

Tapple, P. and T. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3: 123-135.

Tennant, D. L. 1976. Instream flow regimes for fish, wildlife, recreation, and related environmental resources. Page 359-373 *in* J. Orsborn and C. Allman (ed.) Proceedings Special Conference On Instream Flow Needs. Vol 2, American Fisheries Society, Bethesda, MD.

Theurer, F. D., Voos, K. A., and Miller, W. J.. 1984. Instream Water Temperature Model. Instream Flow Inf. Pap. 16. U.S. Fish and Wildlife Service FWS/OBS-84/15. Approx. 200 pp.

Thorne, C. and N. K. Tovey. 1981. Stability of composite river banks. Earth Surface Processes and Landforms 6:469-484.

Thorne, C. 1982. Processes and mechanisms of river bank erosion. *In* Gravel-bed rivers. R. D. Hey, J. C. Bathurst and C. R. Thorne, eds. John Wiley and Sons Ltd. pp.227-271.

Toetz, D. W. 1971. Some observations on the limnology of a pond receiving animal wastes. Proc. Okla. Acad. Sci. 51:30-35.

Torequemada, R. J. and W. S. Platts. 1988. A comparison of sediment monitoring techniques of potential use in sediment/fish relationships. Final Report to Idaho Fish and Game Department, Boise, ID.

Trewartha, G. T., and L. H. Horn. 1980. An introduction to climate. McGraw-Hill Book Company, 415p.

U.S. Environmental Protection Agency. 1986. Water Quality Criteria. EPA 440/5-86-001. Wash. D.C.

U.S. Environmental Protection Agency. 1987. Controlling nonpoint source pollution--a guide. U.S. Environmental Protection Agency, Criteria and Standards Division, Washington, D.C.

U.S. Fish and Wildlife Service. 1984. Fish Passage Action Program for Red Bluff Diversion Dam. Annual Progress Report.

USDA Forest Service. 1975. Stream reach inventory and channel stability evaluation. Region 1 Missoula, Montana. 26p.

USDA Forest Service. 1985. Net economic value of cold and warm water fishing in Idaho. Res. Bul. RM-11. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 20p.

USDA Forest Service. 1985. Water information management system handbook. FSH 2509.17, Chapter 30, Procedure for quantifying channel maintenance flows. Washington, D.C.

VanDeventer, J. S., and W. S. Platts. 1989. Microcomputer software system for generating population statistics from electrofishing data: User's guide for MicroFish 3.0. USDA Forest Service, Intermountain Research Station General Technical Report INT-254.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal Fisheries and Aquatic Sciences. 37:130-137.

Vanoni, V. 1975. Sedimentation engineering. ASCE, New York, NY. 745 p.

Vasiliev, O. F. 1987. System modelling of the interaction between surface and ground waters in problems of hydrology. Hydrological Sciences Journal 32:297-311.

Wagner, F. H. 1978. Livestock grazing and the livestock industry. *In* Wildlife and America, U.S. Commission on Environmental Quality. Washington, D.C.

Wagner F. W. 1978. Evaluating proposed improvement on public rangelands. Transactions of the 43rd North American Wildlife and Natural Resources Conference. pp. 453-553.

Ward, J. V. 1974. A temperature-stressed stream ecosystem below a hypolimnial release mountain reservoir. Arch. Hydrobiol. 74:247-275.

Warren, C. E. 1979. Toward classification and rationale for watershed management and stream protection. U. S. Environmental Protection Agency Ecological Research Series. EPA-600/3-79-059.

Warren, C. E., and W. J. Liss. 1983. Systems classification and modeling of watersheds and streams. Unpublished report, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

Wertz, W. A., and J. F. Arnold. 1972. Land systems inventory. USDA Forest Service, Intermountain Region, Ogden, UT.

Wesche, T. A., and P. A. Rechard. 1980. A summary of instream flow methods for fisheries and related research needs. Eisenhower Consortium Bulletin Number 9. Eisenhower consortium for Western Environmental Forestry Research, U. S. Government Printing Office, Washington, DC.

Wesche, T. A., V. Hasfurther, Q. Skinner, and W. Hubert. 1983. Development of a methodology to determine flushing flow requirements for channel maintenance purposes. Research proposal submitted to Wyoming Water Research Center.

Wolman, M. G., and L. G. Leopold. 1956. River flood plains: Some observations on their formation, U.S. Geological Survey Professional Paper 282-C:87-109.

Wolman, M. G. 1959. Factors influencing erosion of a cohesive river bank. American Journal of Science 257:204-216.

Wolman, M. G., and J. P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. Journal of Geology 68:54-74.

Wolman, M. G. and R. Gerson. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. Earth surface processes 3:189-208.

Young, J. A., R. A. Evans, and P. T. Tueller. 1976. Great Basin plant communities -- pristine and grazed. Pages 187-215 *In* Holocene Environment; change the Great Basin. Nevada Archeological Survey Research Paper Number 6.

Youngblood, A. P., W. G. Padgett, and A. H. Winward. 1985. Riparian community type classification of eastern Idaho - western Wyoming. R4-Ecol-85-01. USDA Forest Service, Intermountain Region, Ogden, UT.

Zimmerman, R. C., J. C. Goodlett and G. H. Comer. 1967. The influence of vegetation on channel form of small streams. *In* Symposium on river morphology, Int. Assoc, Sic. Hydrol. Pub.75:255-275.

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APPENDIX A. GLOSSARY

ACEC - Area of critical environmental concern where special management is needed to protect important historical, cultural, scenic, and natural areas or to identify areas hazardous to human life and property.

Acre-Foot - A measure of water or sediment volume equal to the amount which would cover an area of 1 acre to a depth of 1 foot (325,851 gallons).

Actual Use - The use made of forage on any area by livestock and/or game animals without reference to permitted or recommended use. It is usually expressed in terms of animal-unit months or animal-units.

Adjustment - Change in animal numbers, season of use, kinds or classes of animals, or management practices as warranted by specific conditions.

Allotment - An area designated for the use of a prescribed number and kind of livestock under one plan of management, cf. *community allotment.* Syn. *range allotment.*

Allowable Use - (1) The degree of use estimated to be proper until *proper use* is known. Thirty to fifty percent of the annual growth by weight is often used as a rule of thumb on ranges in good or excellent condition. (2) The amount of forage planned to be used in order to accelerate range improvement.

Alternative - One of several policies, plans, or projects proposed for decision making.

Analysis of the Management Situation (AMS) - A determination of the ability of the planning area to supply goods and services in response to society's demand for those goods and services.

Animal-Day - One day's tenure upon range by one animal. Not synonymous with *animal-unit* day.

Animal-Month - A month's tenure upon range by one animal. Not synonymous with *animal-unit* month.

Animal-Unit - Considered to be one mature (1000 lb.) cow or the equivalent based upon average daily forage consumption of 26 lbs. dry matter per day. Abbr. A.U. cf. *animal-unit conversion factor.*

Animal-Unit Conversion Factor - A numerical figure expressing the forage requirements of a particular kind or class of animal relative to the requirement for an *animal-unit.* A conversion factor is satisfactory with respect to the amount of forage required to maintain an animal, but may not be applicable in determining stocking rates for range use for particular kinds or classes of animals because of different *grazing preferences.*

Animal-Unit Month - (1) The amount of feed or forage required by an *animal-unit* for one month. (2) Tenure of one animal-unit for period of one month. Not synonymous with *animal-month.* Abbr., A.U.M.

Annual Plant - A plant that completes its life cycle and dies in 1 year or less.

Annual Range - Range on which the principal forage plants are self-perpetuating annual, herbaceous species.

Apparent Trend - An estimate of trend drawn from the presence or absence of indicators noted or measured during a one-time observation. Conclusion drawn from such a method can be borne out or refuted only by making additional observations or measurements over time.

Aquifer - A geologic formation capable of transmitting water through its pores at a rate sufficient for water supply purposes. The term water-bearing is sometimes used synonymously with aquifer when a stratum furnishes water for a specific use. Aquifers are usually saturated sands, gravel fractures, caverns, or vesicular rock.

Arid - A term applied to regions or climates where lack of sufficient moisture severely limits growth and production of vegetation. The limits of precipitation vary considerably according to temperature conditions, with an upper annual limit for cool regions of 10 inches or less and for tropical regions as much as 15 to 20 inches. cf. *semiarid.*

Assessment - The Forest and Rangeland Renewable Resource Assessment required by the Resources Planning Act (RPA).

A.U. - Abbreviation for *animal-unit.*

A.U.M. - Abbreviation for *animal-unit month.*

Available Forage - That portion of the forage production that is accessible for use by a specific kind or class of grazing animal.

Balanced Operation - A range livestock enterprise that provides enough feed and forage each season for continuous maintenance and production of its livestock and wildlife.

Band - Any number of sheep handled as a unit attended by a herder. cf. *consolidated, drop and dry band.*

Basal Area - (1) (range) - The area of ground surface covered by the stem or stems of a range plant, usually measured 1 inch above the soil in contrast to the full spread of the foliage. (2) (forestry) - The area of the cross-section at breast height of a single tree or of all the trees in a stand, usually expressed in square feet. This may be measured inside or outside the bark, usually the latter.

Baseline - With respect to soils, the amount of erosion and sedimentation due to natural sources in the absence of human activity.

Base Property - Those lands in a ranching enterprise which are owned or under long-term control of the operator.

Benefit - The total value of an output or other effect.

Beneficial Use - Any of the uses of water including fish, wildlife, agriculture, recreation, aesthetics, or any other use in the public interest.

Beneficial Use Monitoring - Evaluating riverine-riparian constituents to determine condition or change in the status of uses, or to determine potential condition.

Best Management Practice (BMP) - A practice or combination of practices that are the most effective and practical (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

Best Management Practices Effectiveness Monitoring - A combined on-site assessment of BMP adequacy, transport of pollutants, and beneficial use status to determine the effect of a nonpoint source activity on beneficial uses.

Biennial - A plant that lives for two years, producing vegetative growth the first year and usually blooming and fruiting in the second year and then dying.

Biological Potential - The maximum possible output of a given resource, limited only by its inherent physical and biological characteristics.

Biomass - The sum total of living plants and animals above and below ground in an area at a given time.

British Thermal Unit - The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Browse - (n.) That part of leaf and twig growth of shrubs, woody vines and trees available for animal consumption. (v.) To consume browse. cf. *graze*.

Brush - A growth of shrubs or small trees usually undesirable for livestock or timber management. It may sometimes be of value for browse and for watershed protection.

Bucking Pasture - A pasture or area where livestock (refers mainly to sheep) are held for breeding purposes.

Candidate Species - Species designated as candidates for listing as threatened or endangered by the Fish and Wildlife Service or National Marine Fisheries Service.

Canopy - The vertical projection downward of the aerial portion of shrubs and trees, usually expressed as percent of ground so occupied.

Capability - The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends upon current conditions and site conditions such as climate, slope, landform, soils and geology, as well as the application of management practices, such as silviculture or protection from fire, insects, and disease.

Capability Zone - Land capability zones used in FORPLAN. Capability zones were developed by combining the 16 landtype associations described in Wendt, Thompson and Larson's "Land Systems Inventory, Boise National Forest," with subsections developed in Arnold's "Idaho Batholith Source Book."

Carey Act - The acts of August 18, 1894 (28 Stat. 372), and March 15, 1910 (36 Stat. 237, 43 U. S. C. Sec 643), which provide for grants of desert lands to states for disposition to bona fide settlers.

Carrying Capacity - The maximum *stocking rate* possible without inducing damage to vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production. Syn. *grazing capacity*.

Class of Animal - Age and/or sex-group of a kind of animal. Example: cow, calf, yearling, ewe, doe, fawn, etc.

Class of Livestock - Age and/or sex-group of a *kind of livestock.* cf. *class of animal.*

Climax - The highest ecological development of a plant community capable of perpetuation under the prevailing climatic and edaphic conditions.

Close Herding - Handling a herd in a closely bunched manner, restricting the natural spread of the animals when grazing.

Closed Range - Any range on which grazing or other use is prohibited. cf. *livestock exclusion.*

Closure - The administrative order restricting either location, timing, or type of use in a specific area.

Commensurability - Capacity of a permittee's base ranch property to support permitted livestock during the period such livestock are off public land.

Commensurate Property - Land or controlled livestock water that qualifies a person for a grazing privilege, permit, or preference on other land, either public or private.

Common Use - The use of a range by more than one kind of grazing animal either at the same time or at different times within the same growing season. cf. *dual use.*

Community - Any assemblage of populations of plants and/or animals in a common spacial arrangement.

Community Lifestyles - The ways in which residents conduct their everyday routines and how the "way they live" is associated with the National Forest.

Complete Protection - (1) Exclusion of all grazing mammals from an area, usually for an extended period. (2) Withdrawal of all livestock from a given range for an entire *grazing season* or year.

Condition Class - See *range condition class.*

Continuous Grazing - The grazing of a specific unit by livestock throughout a year or for that part of the year during which grazing is feasible. The term is not necessarily synonymous with *yearlong grazing.*

Conversion Factor - See *animal-unit conversion factor.*

Cool Season - Includes spring, early summer, fall and winter.

Cool Season Plant - A plant which generally makes the major portion of its growth during the winter and early spring. cf. *warm-season plant.*

Corridor - A linear strip of land identified for the present or future location of transportation or utility rights-of-way within its boundaries.

Cost-effectiveness - Achieving specified outputs or objectives under given conditions for the least cost.

Deteriorated Range - Range on which present vegetation and soil conditions represent a significant departure from *natural potential*. Syn., *degenerated range*.

Diameter at Breast Height - The diameter of a tree measured 4 feet, 6 inches above the ground.

Direct Outputs - Resource outputs that are caused by an action and occur at the same time and place.

Diversity - The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

Draft Environmental Impact Statement - The statement of environmental effects which is required for major Federal actions under Section 102 of the National Environmental Policy Act and released to the public and other agencies for comment and review.

Drift - v. (1) Movement of materials by wind or water. (2) Natural movement of animals. n. Vegetative material moved and deposited by wind and water.

Drift Fence - An open-ended fence used to retard or alter natural movement of livestock. Generally used in connection with barriers.

Drive - The moving of livestock under human direction.

Dry Meadow - A meadow dominated by grasses which is characterized by soils which become moderately dry by mid-summer. cf. *meadow* and *wet meadow*.

Dual Use - The use of range by two kinds of livestock within the same growing season. cf. *common use*.

Ecosystems - An interacting system of organisms considered together with their environment; for example, marsh, watershed, and lake ecosystems.

Ecological Site - In range terms its a kind of land with a specific potential natural community and specific physical site characteristics, differing from other kinds of land in its ability to produce vegetation and to respond to management.

Ecological Status - The present state of vegetation and soil protection of an ecological site in relation to the potential natural community for the site. Vegetation status is the expression of the relative degree to which the kinds, proportions, and amounts of plants in a community resemble that of the potential natural community. Soil status is a measure of present vegetation and litter cover relative to the amount expected if the potential natural plant community were present.

Edge - Area where plant communities meet or where successional stages or vegetation conditions within the plant communities come together.

Effects - Environmental consequences as a result of a proposed action. Included are direct effects, which are caused by an action and occur at the same time and place, and indirect effects, which are caused by an action and are later in time or further removed in distance, but which are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effective Ground Cover - All vegetative material within three feet of the exposed soil surfaces as well as any additional litter, rock, and rock fragments that are in contact with the soil surface.

Emergency Feeding - Supplying feed to range animals when forage is insufficient due to storms, fires, or other emergencies. cf. *maintenance feeding, supplemental feeding.*

Endangered Species - Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range. Plants or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.

Endemic Plant - A plant confined to a certain country or region and with a comparatively restricted geographic distribution.

Enhancement - A short-term management alternative which is done with the expressed purpose of increasing positive visual variety where little variety now exists.

Environmental Analysis - An analysis of alternative actions and their predictable short- and long-term environmental effects, which include physical, biological, economic, social, and environmental design factors and their interactions.

Environmental Assessment - The concise public document required by the regulations for implementing the procedural requirements of NEPA (40 CFR 1508.9).

Environmental Impact Statement (EIS) - A statement of the environmental effects of a proposed action and alternatives to it. It is required for major federal actions under Section 102 of the National Environmental Policy Act (NEPA) and released to the public and other agencies for comment and review. It is a formal document that must follow the requirements of NEPA, the Council on Environmental Quality (CEQ) guidelines, and directives of the agency responsible for the project proposal.

Erosion Pavement - A concentration of gravel or coarser fragments that remains on the soil surface after finer particles have been removed by running water or wind.

Evaluation Criteria - Standards developed for appraising alternatives.

Exclosure - An area fenced to exclude animals.

Extensive Grazing - Management seeks full utilization of forage allocated to livestock. Cost-effective management systems and techniques, including fencing and water development, are designed and applied to obtain relatively uniform livestock distribution and use of forage and to maintain plant vigor.

Feed - n. Harvested grain, hay or other processed food provided to animals. cf. *forage.*

Feed Reserve - Feed stored for future use. cf. *forage reserve.*

Feeding Supplements - Additional feed, nutrients, or vitamins added to the forage the livestock can get on their own. Usually during winter conditions when forage is not easily accessible or is nonexistent.

Fibrous Root System - A plant root system having a large number of small, finely divided, widely spreading roots, but no large taproots. Typified by grass root system. cf. *taproot system.*

Floodplains - The lowland and relatively flat area adjoining inland waters, including, at a minimum, that area subject to a 1 percent or greater chance of flooding in any given year.

FLPMA - Federal Land Policy and Management Act of October 21, 1976 (Public Law 94-579, 90 Stat. 2743), commonly called the "Organic Act" for the BLM.

Forage - (n.) All browse and herbaceous foods that are available to grazing animals. It may be grazed or harvested for feeding. cf. *concentrate feed and cured and range forage.* (v.) Act of consuming forage. Syn., *graze.*

Forage Production - The weight of forage that is produced within a designated period of time on a given area. The weight may be expressed as either green, air-dry or over-dry. The term may also be modified as to time of production such as annual, current year's or seasonal forage production.

Forb - Any herbaceous plant other than those in the *Gramineae (or Poaceae), Cyperaceae and Juncacea* families.

Forest and Rangeland Renewable Resources Planning Act of 1974 - An Act of Congress requiring the preparation of a program for the management of the National Forests' renewable resources and of land and resource management plans for units of the National Forest System. It also requires a continuing inventory of all National Forest System lands and renewable resources.

FORPLAN - A linear programming system used for developing and analyzing Forest planning alternatives.

Frequency - A quantitative expression of the presence or absence of individuals of a species in a population; i.e., the ratio between the number of sample units that contain a species and the total number of sample units.

Full Use - The maximum use during a grazing season that can be made of range forage under a given grazing program without inducing a downward trend in range condition.

Goal - A concise statement that describes a desired condition to be achieved sometime in the future. It is normally expressed in broad, general terms and is timeless in that it has no specific date by which it is to be completed. Goal statements form the principal basis from which objectives are developed.

Grass/Forb - An early forest successional stage where grasses and forbs are the dominant vegetation.

Grazing -
Extensive Grazing - Range on which the level of investment for improvement practices and management is low.
Intensive Grazing - Range on which the level of investment for improvement practices and management is high.
Switchback Grazing - A series of grazing and deferment involving two units.
Spot Grazing - Repeated grazing of small areas while adjacent areas are lightly grazed or unused.
Flash Grazing - Stocking at a high intensity for a short duration.
Intermittent Grazing - Grazing range or artificial pasture for indefinite periods at indefinite intervals.

Grazing Capacity - The maximum stock rate possible without inducing damage to vegetation or related resources.

Grazing District - An administrative subdivision of the rangelands under jurisdiction of the BLM established pursuant to Section 3 of the Taylor Grazing Act to facilitate management of rangeland resources.

Grazing Distribution - Dispersion of livestock grazing within a management unit or area. Syn. *livestock distribution.*

Grazing Formula - The specific order of grazing or sequence within a grazing strategy.

Grazing Lease - An authorization that permits the grazing of livestock on public lands outside the grazing districts during a specified period of time (Section 15 of the Taylor Grazing Act).

Grazing Management - Manipulation of grazing to achieve a desired result.

Grazing Period - The length of time that livestock are grazed on a specific area.

Grazing Preference - (1) Selection of certain plants over others by grazing animals. (2) In the administration of public lands, a basis upon which permits and licenses are issued for grazing use. cf. *grazing privilege and grazing right.*

Grazing Pressure - The animal-to-forage ratio at a specific time, e.g., 3 animal-units per ton of standing forage. cf. *stocking pressure.*

Grazing Privilege - Permitted use of lands for grazing. cf. *grazing right.*

Grazing Right - A right to graze public lands, permanently vested in the beneficiary as specified by the terms of the law or a contract.

Grazing Season - On public lands, an established period for which grazing permits are issued. May be established on private land in a *grazing management plan.*

Grazing Strategies - A specialization of *grazing management* which defines systematically recurring periods of grazing and deferment for two or more pastures or management units. cf. *deferred grazing, intermittent grazing, deferred-rotation grazing, and short duration grazing.* Descriptive common names such as "Merrill," "Hormay," "South African switchback," etc. may be used. However, it is common in the range profession to follow the first usage of a grazing system name with a standard format. This format consists of a numerical description in the following prescribed order:[the number of pastures (or units)-number of herds; length of grazing periods; length of deferment periods for any given unit in the system followed by an abbreviation of the unit of time used].

Examples:
1. Merrill system [4-3;12:4 mo.] is a grazing system with 4 pastures, 3 herds of livestock, a 12 month grazing period and a 4 month deferment period.
2. South African switchback [2-1;3:3,6:3,3:6 mo.] is a grazing system with 2 pastures, 1 herd, and a grazing cycle of 3 months grazing, 3 month deferment, 6 months grazing 3 months deferment, 3 months grazing 6 months deferment.
3. [14-1;12:156 da.] A grazing system consisting of 14 pastures, 1 herd, a 12 day grazing period and a 156 day deferment period.

Grazing Unit - An area that is grazed as an entity.

Growing Season - The months of the year during which a species of vegetation grows.

Ground Cover - The percentage of material, other than bare ground, covering the land surface. It may include live vegetation, standing dead vegetation, litter, cobble, gravel, stones, and bedrock. Ground cover plus bare ground would total 100 percent.

Ground Water - The subsurface water supply in the saturated zone below the water table.

Guideline - An indication or outline of policy or conduct; i.e., any issuance that assists in determining the course of direction to be taken in any planned action to accomplish a specific objective.

Habitat - The place where a plant or animal naturally or normally lives or grows.

Habitat Diversity Index - A measure of habitat diversity improvement expressed as a percentage of optimum size class distribution that is achieved over time.

Habitat Grouping - Grouping of habitat types in logical categories to facilitate resource planning.

Habitat Type - The aggregate of all areas that support or can support the same primary vegetation at climax.

Heavy Grazing - A comparative term which indicates that the stocking rate of a pasture is relatively greater than that of other pastures. Often erroneously used to mean *overuse*. cf. *light and moderate grazing.*

Hedged - A term used to described the appearance of woody plants that have been repeatedly browsed so as to appear artificially clipped.

Hedging - The persistent browsing of terminal buds of browse species causing excessive lateral branching and a reduction in upward growth.

Herb - Any flowering plant except those developing persistent woody stems above ground.

Herding - Handling or tending of a *herd*. cf. *close, open, and trail herding.*

High-Intensity, Low-Frequency Grazing - Syn. *short-duration grazing.*

High Performance Grazing - (HPG) grazing that favors the animal or the production of meat from the animal.

High Utilization Grazing - (HUG) Utilization that forces the use of less palatable plants.

Holding Ground - An area where livestock are held during roundups. Syn. *bunch ground.*

Horizontal Diversity - The distribution and abundance of difference plant and animal communities or successional stages across an area of land; the greater the number of communities, the higher the degree of horizontal diversity.

Hot Season Grazing - Usually considered to be between July 10 and September 1, with some altitudinal differences.

Ice-Cream Species - An exceptionally palatable species sought and grazed first by livestock and game animals. Such species are usually overutilized under proper grazing.

__Implementation__ - Those activities necessary to respond to the approved Land and Resource Management Plan.

__Incidental Grazing__ - Grazing use that occurs on lands not managed for the production of domestic livestock. May occur as a result of natural herd movement, trailing of livestock, or the use of domestic livestock in recreation.

__Increaser Plants__ - Plant species of the original vegetation that increase in relative amount, at least for a time, under *overuse*.

__Indicator Species__ - (1) Species that indicate the presence of certain environmental conditions, seral stages or previous treatment. (2) One or more plant species selected to indicate a certain level of grazing use.

__Infiltration__ - The downward entry of water into the soil.

__Instream Flows__ - Those nonconsumptive on-site quantities of water necessary to meet seasonal streamflow requirements to accomplish the purposes of the National Forests including, but not limited to, maintenance of favorable conditions of water flow, fisheries, visual quality, and recreational opportunities at acceptable levels.

__Intensive Grazing__ - Grazing management that controls distribution of cattle and duration of use on the range, usually by fences, so parts of the range are rested during the growing season.

__Interdisciplinary Approach__ - The utilization of individuals representing two or more areas of knowledge and skills focusing on the same task, problem, or subject. Team member interaction provides necessary insight to all stages of the process.

__Intermittent Streams__ - A stream which flows only at certain times of the year when it receives water from springs or from some surface source such as melting snow in mountainous areas.

__Invader__ - Plant species that were absent or present in very small amounts in undisturbed portions of the original vegetation of a specific range site and will invade following disturbance or continued *overuse*.

__Irreversible__ - Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity. Irreversible also includes loss of future options.

__Key Area__ - (1) A portion of range, which, due to its location, its grazing or browsing value, and/or its use, serves as an indicative sample of range conditions, trend, or degree of use seasonally. A key area guides general management of the entire area of which it is a part. (2) An area upon which the success of a ranching operation largely depends.

__Key Management Species__ - Forage species on which management of grazing of a specific unit is based.

__Key Species__ - (1) Forage species whose use serves as an indicator to the degree of use of associated species. (2) Those species which must, because of their importance, be considered in the management program.

__Land Capability__ - The suitability of land for use without permanent damage. Land capability, as ordinarily used in the United States, is an expression of the effect of physical land conditions, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land capability involves consideration of (1) the risks of land damage from erosion and other causes and (2) the difficulties in land use owing to physical land characteristics, including climate.

Land Systems Inventory (LSI) - A land stratification system based on geomorphic principles, described in Thompson and Larson's "Land Systems Inventory, Boise National Forest."

Land Use Planning - The process by which decisions are made on future land uses over extended time periods that are deemed to best serve the general welfare. Decision-making authorities on land uses are usually vested in state and local governmental units, but citizen participation in the planning process is essential for proper understanding and implementation, usually through zoning ordinances.

Landtype - Visually identifiable unit areas resulting from homogeneous geomorphic and climatic processes and having defined patterns of soils and vegetative potentials.

Landtype Association - A grouping of landtypes representing the broadest level in the land stratification system. Obvious elements of soils, landform and vegetation are distinguishing factors.

Light Grazing - A comparative term which indicates that the stocking rate of one pasture is relatively less than that of other pastures. Often erroneously used to mean *underuse*. cf. *heavy and moderate grazing.*

Line Officer - Management personnel within the agency with decision-making authority. An example in the Forest Service would be the Secretary of Agriculture, Chief, Regional Forester, Forest Supervisor, and District Ranger.

Litter - The uppermost layer of organic debris on the soil surface; essentially the freshly fallen or slightly decomposed vegetal material.

Livestock Exclusion - Range that is closed to grazing by livestock. cf. *closed range.*

Livestock Flexibility - Ability to alter the number, kind, or class of animals in a livestock enterprise, as warranted by variability in forage, economic, weather, or other conditions.

Livestock Management - Application of technical principles and business methods to livestock production.

Livestock Production - (1) The weight or number of animals that a specific range, tame pasture, or management system produces per unit of time. (2) The business of producing livestock.

Long-Term Trend - Change in either vegetal or soil condition from the time the study was established until the most recent evaluation.

Management Area - An area of land with similar management goals and a common management prescription.

Management Concern - An issue, problem, or a condition which constrains the range of management practices identified by the Forest Service in the planning process.

Management Direction - A statement of multiple-use and other goals and objectives, the associated management prescriptions, and standards and guidelines for attaining them.

Management Indicator Species - A species selected because its population changes indicated effects of management activities on the plant and animal community. A species whose condition can be used to assess the impacts of management actions on a particular area.

Management Practice - A specific activity, measure, course of action, or treatment.

Management Prescription - Management practices and intensity selected and scheduled for application on a specific area to attain multiple-use and other goals and objectives.

Mesic - Refers to environmental conditions that have medium moisture supplies rather than hydric (wet) or xeric (dry) conditions.

Minimum Streamflows - A specified level of flow through a channel that must be maintained by the users of streams for biological, physical, or other purposes.

Mitigation - Actions to avoid, minimize, reduce, eliminate, or rectify the impact of a management practice.

Model - A representation of reality used to describe, analyze, or understand a particular concept. A "model" may be a relatively simple qualititative description of a system or organization, or a highly abstract set of mathematical equations.

Moderate Grazing - A comparative term which indicates that the stocking rate of a pasture is between the rates of other pastures. Often erroneously used to mean *proper use*. cf. *heavy and light grazing.*

Monitoring and Evaluation - The periodic evaluation on a sample basis of Forest Plan management practices to determine how well objectives have been met and how closely management standards have been applied.

Multiple Use - Harmonious use of range for more than one purpose; i.e., grazing of livestock, wildlife production, recreation, watershed and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output. Syn., *multiple land use.*

National Environmental Policy Act (NEPA) - An Act to declare a National policy which will encourage productive and enjoyable harmony between man and his environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man, to enrich the understanding of the ecological systems and natural resources important to the Nation and to establish a Council on Environmental Quality.

National Forest Land and Resource Management Plan - A Plan developed to meet the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended, that guides all natural resource management activities and establishes management standards and guidelines for the National Forest System lands of a given National Forest.

National Forest Management Act (NFMA) - A law passed in 1976 as an amendment to the Forest and Rangeland Renewable Resources Planning Act requiring the preparation of Regional Guides and Forest Plans and the preparation of regulations to guide that development.

National Forest System (NFS) Lands - National Forests, National Grasslands, or purchase units, and other lands under the management of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

Native Vegetation - Those plant species, communities, or vegetative associations which are endemic to a given area and which would normally be identified with a healthy and productive range condition occurring as a result of the natural vegetative process of the area.

Natural Barrier - A natural feature that will restrict livestock movements such as a dense stand of trees or downfall.

Natural Potential - With reference to range vegetation, sometimes erroneously used synonymously with climax.

No-Action Alternative - The most likely condition expected to exist in the future if current management direction were to continue unchanged.

Nonconsumptive Use - That use of a resource that does not reduce the supply. For example, nonconsumptive use of water includes hydroelectric power generation, boating, swimming, and fishing.

Nonpoint Source Pollution - Sources of pollution that are diffuse in origin, their transportation into receiving water not well defined or constant, and their discharge occurring at many diffuse locations and depending heavily on weather conditions such as rainstorms or snowmelt. Pollution from forest management is of this type.

Non-Selective Grazing - Utilization of forage by grazing animals in such a way that all forage species and plants are grazed to a comparable degree. It is generally achieved by using a high stocking density for a short grazing period.

Nonuse - (1) Absence of grazing use on current year's forage production. (2) Lack of exercise temporarily, of a grazing privilege on grazing lands. (3) An authorization to refrain, temporarily, from placing livestock on public ranges without loss of preference for future consideration.

Normal Channel Dynamics - Refers to adjustments that occur as part of normal channel-riparian function under dynamic equilibrium conditions.

Noxious Weeds - A plant species that is undesirable--conflicts, restricts, or otherwise causes problems with management objectives.

Objective - A concise, time-specific statement of measurable planned results that responds to pre-established goals. An objective forms the basis for further planning to define the precise steps to be taken and the resources to be used in achieving identified goals.

Open Herding - Allowing a herd to spread naturally while grazing.

Open Range - (1) Range not fenced into management units. (2) All suitable range of an area in which grazing is permitted. (3) Untimbered range. (4) Range on which the livestock owner is not required to confine his livestock.

Operator - An individual, group, association, or corporation authorized to conduct livestock grazing on public lands.

Optimum - A level of production that is consistent with other resource requirements as constrained by environmental, social, and economically sound conditions.

Outputs - The goods, services, products, and concerns which are measurable and capable of being used to determine the effectiveness of programs and activities in meeting objectives. Goods, end products, or services that are purchased, consumed, or utilized directly by people. A broad term for describing any result, product, or service that a process or activity actually produces.

Overgrazed Range - A range that has *deteriorated* and may still be deteriorating from its productive potential dues to *overgrazing.*

Overgrazing - Continued *overuse* creating a *deteriorated range.*

Overstocking - Placing a number of animals on a given area that will result in *overuse* if continued to the end of the planned grazing period. Not to be confused with *overgrazing* because an area may be overstocked for a short period, but the animals may be removed before the area is *overused.* However, continued *overstocking* will lead to *overgrazing.*

Overstory - That portion of the trees, in a forest of more than one story, forming the upper or uppermost canopy.

Overuse - Using an excessive amount of the current year's plant growth, such that, if continued, will result in *overgrazing and range deterioration.* Syn. *overutilization.*

Palatability - The relish with which a particular species or plant part is consumed by an animal.

Pasture - (1) A grazing area enclosed and separated from other areas by fence. (2) Forage plants used as food by grazing animals.

Pedestaled - A condition where the soil has eroded from around individual plants or other objects such as a small rick, leaving them on small pedestals of soil; sometimes the result of frost heaving.

Percent Use - Grazing use of the current season's plant growth, usually expressed as a percent of weight removed. cf. *use.*

Percolation - The downward movement of water through the soil.

Permittee - One who holds a permit to graze livestock on state, federal, or certain privately-owned lands.

Phenology - The study of periodic biological phenomenon, such as flowering, seeding, etc., especially as related to climate.

Planning Area - The area of National Forest land covered by a Regional Guide or Forest Plan.

Planning Criteria - Standards, tests, rules, and guidelines by which the planning process is conducted and upon which judgments and decisions are based.

Policy - A guiding principle which is based on a specific decision or set of decisions.

Potential Natural Community - The biotic community that would become established if all successional sequences were completed without interference by man under the present environmental conditions.

Practices - Those management activities that are proposed or expected to occur.

Preferred Species - Plant species preferred by animals and grazed first.

Premature Grazing - Grazing before *range readiness.*

Primary Range - Areas which animals prefer to use when management is limited. Primary range will be overused before *secondary range* is fully used when animals are allowed to shift for themselves.

Production Potential - The capability of the land or water to produce a given resource.

Program - When capitalized, the Renewable Resource Program required by the RPA. Generally, sets of activities or projects with specific objectives, defined in terms of specific results and responsibilities for accomplishment.

Program Development and Budgeting - The process by which activities for the Forest are proposed and funded.

Project Design - The process of developing specific information related to location, timing, activities, accountability, and control that result in the achievement of an objective or desired future condition.

Proper Grazing - The act of continuously obtaining proper use.

Proper Stocking - Placing a number of animals on a given area that will result in proper use at the end of the planned grazing period. Continued proper stocking will lead to proper grazing.

Proper Use - A degree and time of use of current year's growth which, if continued, will either maintain or improve the range condition consistent with conservation of other natural resources. Syn. *proper utilization.*

Proposed Action - In terms of the National Environmental Policy Act, the project, activity, or decision that a Federal agency intends to implement or undertake.

Public Domain Lands - Original public domain lands that have never left federal ownership; also lands in federal ownership that were obtained by the government in exchange for public domain lands or for timber on public domain lands. One category of public lands.

Public Issue - A subject or question of widespread public interest relating to management of the National Forest System.

Range - Embraces *rangelands* and also many *forest lands* which support an understory or periodic cover of herbaceous or shrubby vegetation amenable to certain range management principles or practices. Syn. *veld.* cf. *grazable woodland.*

Range Allotment - An area designated for use of a prescribed number and kind of livestock under one management plan.

Range Analysis - Systematic acquisition and evaluation of rangeland resources data needed for planning allotment management and overall land management. It consists of two basic parts: (1) an inventory of the resource and (2) a narrative evaluation of the resource data, range management alternatives, and other information relevant to management of the grazing area.

Range Appraisal - The classification and valuation of rangeland from an economic or production standpoint.

Range Condition - The current productivity of a range relative to what that range is naturally capable of producing. Reflects the state of the range-ecoystem in relation to its potential.

Range Condition Class - One of a series of arbitrary categories used to classify *range condition* and usually expressed as excellent, good, fair, or poor.

Range Condition Trend - The direction of change in range condition. Syn. *range trend and trend in range condition.*

Range Degeneration - The process whereby the same area becomes successively occupied by different plant communities of lower ecological order. Syn. *range retrogression.*

Range Forage - Forage produced on range. cf. *forage, cured forage.*

Range Improvement - (1) Any structure or excavation to facilitate management of range or livestock. (2) Any practice designed to improve range condition or facilitate more efficient utilization of the range. (3) An increase in the grazing capacity of the range, i.e., improvement in *range condition.*

Range Management - A distinct discipline founded on ecological principles and dealing with the husbandry of rangelands and range resources.

Range Readiness - The defined stage of plant growth at which grazing may begin under a specific management plan without permanent damage to vegetation or soil. Usually applied to seasonal range.

Range Site - A distinctive kind of rangeland, which in the absence of abnormal disturbance and physical site deterioration, has the potential to support a native plant community typified by an association of species different from that of other sites. This differentiation is based upon significant differences in kind or proportion of species, or total productivity. cf. *vegetation type.*

Range States - Generally considered as the 17 western U.S. states, excluding Alaska and Hawaii. In the range states, the major portion of land is used for producing livestock from range.

Range Suitability - The adaptability of a range to grazing by livestock and/or game.

Rangeland - Land on which the native vegetation (climax or natural potential) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. Includes lands revegetated naturally or artificially to provide a forage cover that is managed like native vegetation. Rangelands include natural grasslands, savannahs, shrublands, most deserts, tundra, alpine communities, coastal marshes and wet meadows. cf. *range.*

Rapid Channel Response - Refers to channel adjustments that occur rapidly in response to sudden changes in the long-term equilibrium condition controlling factors; or to the exceedence of critical geomorphic thresholds.

Record of Decision - A document separate from but associated with an Environmental Impact Statement that publicly and officially discloses the Environmental Impact Statement to implement.

Rest Period - A period of non-grazing of at least one year included as part of a *grazing strategy*.

Rest-Rotation - Complete rest of each pasture in a subdivided range during 1 year within a cycle of several years. See *grazing strategies*.

Revocation - Generally, an action that cancels a previous official act; specifically, an action that cancels a withdrawal. Revocation is usually done in conjunction with restoration, which opens the public lands.

Rhizome - A horizontal underground stem, usually sending out roots and above-ground shoots from the nodes.

Riding Down - Pushing over small trees and shrubs by livestock or wildlife in order to reach the browse.

Riparian Areas - Geographically delineated areas, with distinctive resource values and characteristics, that are comprised of the aquatic and riparian ecosystem, floodplains, and wetlands. Some government manuals define them as all areas within a horizontal distance of at least 100 feet from the edge of perennial streams or other water bodies. This definition should not be used. Riparian areas may be associated with lakes, reservoirs, potholes, springs, wet meadows, and ephemeral, intermittent, or perennial streams.

Riparian Complex - Groupings of several riparian community types which are composed of somewhat predictable community type compositions and recur within specific riparian settings. The presence of each complex may be influenced by stream gradient, stream size, valley bottom width, and/or elevation and other factors.

Riparian Community Type - A repeating, classified, defined, and recognizable assemblage of riparian plant species.

Riparian Dependent Resources - Resources that owe their existence to the riverine-riparian area.

Riparian Ecoystems - A transition between the aquatic ecoystem and the adjacent terrestrial ecosystem identified by soil characteristics or distinctive vegetation communities that require free or unbound water.

Riparian Ecosystem/Plant Communities - A transition between the aquatic ecosystem and the adjacent upland terrestrial ecosystem, identified by soil characteristics and distinctive vegetation communities that require free or unbounded water.

Riverine - Vegetation growing in the close proximity of watercourses, or on small islands in river beds.

Rotation Grazing - System of pasture utilization embracing short periods of heavy stocking followed by periods of rest for herbage recovery during the same season. Generally used on *tame pasture* or *cropland pasture*.

Rough - (1) The accumulation of mature living and dead vegetation--especially grasses and forbs--on forest range, marshland, or prairie. (2) May refer to land surface with uneven terrain.

Sacrifice Area - A portion of the range, irrespective of site, that is intentionally overgrazed to obtain efficient overall use of the management area.

Sacrifice Site - A range site that is intentionally overgrazed.

Scoping Process - The public land management activities used to determine the range of actions, alternatives, and impacts to be considered in an Environmental Impact Statement.

Seasonal Distribution - (1) The progressive grazing in a sequence of moves from one part of a range to another as vegetation develops. (2) The normal occurrence of precipitation at different periods of the year.

Seasonal Grazing - Grazing restricted to a specific season. cf. *grazing system, seasonal distribution, seasonal zone.*

Seasonal Use - (1) Synonymous with *seasonal grazing.* (2) Seasonal preference of certain plant species by animals.

Secondary Range - Range which is lightly used or unused by livestock under minimal management and will ordinarily not be fully used until the primary range has been overused.

Sediment - Any material transported, suspended, or deposited by water.

Selective Grazing - The grazing of certain plant species on the range to the exclusion of others.

Sensitive Species - Plant or animal species which are susceptible or vulnerable to activity impacts or habitat alterations.

Sensitivity Analysis - A determination of the effects of varying the level of one or more factors, while holding the other factors constant.

Seral Condition - The unique characteristics of a biotic community which is a developmental, transitory stage in an orderly ecologic succession involving changes in species, structure, and community processes with time.

Short-Duration Grazing - Any *grazing strategies of grazing management* having a stocking density index >2.

Short-Term Trend - Change in either vegetal or soil condition from the previous evaluation until the most recent evaluation.

Shrub/Seedling - A forest successional stage in which shrubs and seedling trees are the dominant vegetation.

Site Index - A numerical evaluation of the quality of land for plant productivity.

Site Preparation - A general term for removing unwanted vegetation, slash, roots and stones from a site before reforestation.

Site Productivity - Production capability of specific areas of land.

Soil Productivity - The capacity of a soil to produce a specific crop such as livestock forage, etc., under defined levels of management. Productivity is generally dependent on available soil moisture and nutrients and length of growing season.

Soil Surveys - Systematic examinations of soils in the field and in laboratories; such examinations are at differing "order" and interpretation according to their adaptability for various crops, grasses, and trees; there are five classed orders of surveys, with order 1 being the highest intensity through order 5 (lowest intensity).

Special Use Permit - A permit issued under established laws and regulations to an individual, organization, or company for occupancy or use of lands for some special purpose.

Spring-Fall Range - Range that is grazed primarily during the spring and fall.

Standing Crop (Standing Crop Biomass, Standing Stock) - The total amount of the biomass of organisms of one or more species within an area. The total number or the total weight of one or more species of animals in an area at a given time.

Stocking Rate (Grazing Rate) - Range management usage. The actual number of animals, expressed in either animal-units or animal-unit months, on a specific area at a specific time.

Stratification - A land use planning concept which subdivides a study area into units which contain the same characteristics.

Streamside Management Zone - A designated zone that consists of the stream and an adjacent area of varying width where management practices that might affect water quality, fish, or other aquatic resources are modified. It is a zone which acts as an effective filter and absorptive zone for sediment; maintains shade; protects aquatic and terrestrial riparian habitats; protects channel and streambanks; and promotes floodplain stability. This zone may be wider than just the riparian area.

Stocking Density - The relationship between number of animals and area of land at any instant of time. It may be expressed as animal-units per acre, animal-units per section or A.U.M./ac. cf. *stocking density index, stocking rate, stocking pressure.*

Stocking Rate - The area of land which the operator has allotted to each animal-unit for the entire grazable period of the year. May be expressed as a ratio in various forms such as A.U./section; ac./A.U.M. cf. *stocking density, stocking pressure.*

Stream - A watercourse having a distinct natural bed and banks; a permanent source which provides water at least periodically, and at least periodic or seasonal flows at times when other recognized streams in the same area are flowing.

Succession, Plant - The process of vegetational development whereby an area becomes successively occupied by different plant communities of higher ecological order.

Successional Stage - A stage or recognizable condition of a plant community that occurs during its development from bare ground to climax; for example, coniferous forests in the Blue Mountains progress through six recognized states: grass-forb; shrub-seedling; pole-sapling; young; mature; old growth.

Suitability - (1) The adaptability of an area to grazing by livestock or wildlife. (2) The adaptability of a particular plant or animal species to a given area. cf. *suitable range, unsuitable range.*

Suitable Range - (1) Range accessible to livestock and which can be grazed on a sustained yield basis without damage to the resource. (2) The limits of adaptability of plant or animal species. cf. *unsuitable range.*

Summer Range - Range that is grazed primarily during the summer growing season.

Terrestrial Ecosystems/Plant Communities - Areas outside of floodplains occupied by vegetation communities that require well-drained soil conditions for at least part of the growing season.

Threatened Species - Those plant or animal species likely to become endangered species throughout all or a significant portion of their range within the foreseeable future.

Trail Herding - Directing and controlling the movement of a group of livestock on restricted overland routes.

Trailing - (1) Controlled directional movement of livestock. cf. *drive.* (2) Natural trailing is the habit of livestock or wildlife to repeatedly tread in the same line or path.

Trampling - Treading under foot; the damage to plants or soil brought about by movements or congestion of animals, including humans.

Transitory Range - Land that is suitable for grazing use of a nonenduring nature over a period of time. For example, on particularly disturbed lands, grass may cover the area for a period of time before being replaced by trees or shrubs not suitable for forage.

Trend - The direction of change in ecological status over time.

Trespass - An unauthorized use of federal lands and/or resources.

Turnout - Act of turning livestock out on the range at the beginning of the *grazing season.*

Type A Channel - These channels generally drain the following landforms: breaklands, mass wasted lands, colluvial drift slopes, and frost-churned uplands. The adjacent landforms are steep with heavy, coarse alluvium or colluvium. The channels are generally contained within narrow valley bottoms with steep slopes or walls (> 50 percent) on either side. The channel form is well-incised and v-shaped with annual peak flows contained. Stream gradient over the reach is normally greater than or equal to 6 percent. Stream order is usually 1-3. The streambed is characterized by bedrock, large rubble, and boulders with a high degree of armoring and low detachment. Major habitat types are dominated by riffles, runs, and pocket water. Pools are formed by large boulders, bedrock outcrops, and large organic debris. Sinuosity ratio equals 1.0 to 1.1. Natural sediment supply is generally low depending on the adjoining landform. Sediment delivery is rapid and efficient.

Type B Channel - These channels generally drain the fluvial dissected slopelands, high alluvial terraces, some colluvial drift slopes, mini-breaklands, and old erosional surfaces. The adjacent landforms have slopes that range from 5 to 50 percent gradients. Stream gradients over the reach vary between 3 and 6 percent. Channel form is moderately incised, broad, and v-shaped with annual peak flows generally contained. Stream order is normally 1-4. The streambed is characterized by small to large boulders, small to large rubble, and coarse gravel with some fine gravel, sand or silt. The substrate is moderately armored with moderate detachment. The habitat-type profile is dominated by pools, riffles, and pocket water. Pools are formed by large organic debris, meanders, and bedrock outcrops. Sinuosity ratio ranges from 1.1 to 1.3. Natural sediment supply is generally moderate with a wide variation in delivery efficiency (low to high) depending on contiguous landforms.

Type C Channel - Type C channels are generally located in moderately wide to very wide valley bottoms. Valley slopes vary considerably, ranging from old erosional surfaces to low relief glaciated uplands. Adjacent landforms are generally low in gradient, containing fine-textured residual soils; however, C channels may also typify high-elevation glaciated troughs and breaklands. Stream gradient over the reach is normally less than or equal to 3 percent. Channel entrenchment is shallow with frequent overbank discharge. The streambed is characterized by large amounts of large and small rubble, coarse and fine gravels with lesser amounts of small boulders, sand and silt. Streambed has little or no armoring with easy detachment. Sinuosity ratio varies from 1.5 to 2.0+. The habitat-type profile is characterized by heterogeneity. High quality pools and runs are more dominant in this channel type. Pools are formed by large organic debris and meanders. Extensive areas of spawning habitat are frequently found in this channel type. Sediment supply is relatively high; however, delivery efficiency from adjoining slopes is low. Streams characterized by a C channel profile are generally considered to provide the highest quality spawning and rearing habitats for salmonids.

Unsuitable Range - An area which may have value for wildlife but has no value for, or should not be used by, livestock because of steep topography, barrenness, dense timber, lack of forage or unstable soils. cf. *suitable range*.

Use - (1) The proportion of current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole. Syn. *degree of use*. (2) The putting of range to a purpose such as grazing, bedding, shelter, trailing, watering, watershed, recreation, forestry, etc.

Use Factor - An index to the grazing use that may be made of forage species, based on a system of range management that will maintain the economically important forage species, or achieve other management objectives such as maintenance of watersheds, recreation values, etc.

Vegetative Management - Activities designed primarily to promote the health of the forest cover for multiple-use purposes.

Vegetation Types - A piece of land which is recognized by its vegetative aspect or the dominant vegetation growing thereon. For example, a patch of aspen, a patch of sagebrush, or a stand of pinyon-juniper would all be separate vegetation types.

Viable Populations - A number of individuals of a species sufficient to ensure the long-term existence of the species in natural self-sustaining populations adequately distributed throughout their region.

Vigor - The relative robustness of a plant in comparison to other individuals of the same species. It is reflected primarily by the size of a plant and its parts in relation to its age and the environment in which it is growing.

Warm-Season Plant - A plant which makes most or all its growth during the spring, summer or fall and is usually dormant in winter.

Water Gap - (1) A specially constructed fence across a drainage. The fence is easily moved by the forces of a flood, thus preventing damage to the permanent fence. (2) An opening or fenced area providing access to a developed or natural water supply permitting one watering facility to serve two or more pastures.

Water Rights - Rights to divert and use water or to use it in place.

Water Yield - The measured output of the forest's streams.

Water Yield Increase - Additional water released to the forest streams as a result of forest management activities.

Watershed - (1) A total area of land above a given point on a waterway that contributes runoff water to the flow at that point. (2) A major subdivision of a drainage basin.

Wet Meadow - A meadow where the surface remains wet or moist throughout the summer, usually characterized by sedges and rushes. cf. *meadow* and *dry meadow*.

Wetlands - Areas that are inundated by surface or groundwater with a frequency sufficient to support and under normal circumstances, does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Wildlife Habitat Diversity - The distribution and abundance of different plant and animal communities and species within a specific area.

Winter Range - Range that is grazed during the winter months.

Withdrawal - An action that restricts the disposition of public lands and that holds them for specific public purposes; also, public lands that have been dedicated to public purposes.

Wolf Plant - (1) A plant that, though of a species generally considered palatable, is not grazed by livestock. (2) An isolated plant growing to extraordinary size, usually from lack of competition.

Yearling - An animal approximately one year of age. A short yearling is from 9 to 12 months of age and a long yearling is from 12 to 18 months.

Yearlong Grazing - *Continuous grazing* for a calendar year.

Yearlong Range - Range that is, or can be, grazed yearlong.

Yield - See *forage production, total annual yield or runoff.*

APPENDIX B. SUGGESTED READING

Adams, S. N. 1975. Sheep and cattle grazing in forests: A review. Journal of Applied Ecology 12(1): 143-152.

Baumgartner, David M. (Ed.). 1981. Interior west watershed management. Proceedings of a Symposium held April 8-10, 1980, Spokane, WA. [Available from: Washington State University, Cooperative Extension, Pullman, WA 99164]

Bohn, Carolyn C.; Buckhouse, John C. 1985. Some responses of riparian soils to grazing management in northeastern Oregon. Journal of Range Management 38(4): 378-381.

Bohn, Carolyn C. 1986. Biological importance of streambank stability. Rangelands 8(2): 55-56.

Buell, James W. 1986. Stream habitat enhancement evaluation workshop: level 1. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Carothers, Steven W. 1977. Importance, preservation and management of riparian habitat: an overview. USDA, Forest Service, General Technical Report RM-43. p. 2-4. *In* Johnson, R. Roy and Jones, Dale A. (Technical Coordinators), Importance, Preservation and Management of Riparian Habitat: a Symposium. Tucson, AZ. July 9, 1977.

Carter, V. 1986. An overview of the hydrologic concerns related to wetlands in the United States. Canadian Journal of Botany 64: 364-374.

Claire, E. W. 1980. Stream habitat and riparian restoration techniques: guidelines to consider in their use. *In* Proceedings of a Workshop for Design of Fish Habitat and Watershed Restoration Projects. County Squire, OR. March 10-14, 1980.

Clifton, Catherine Faye. 1987. Effects of vegetation and land use on the channel morphology of Wickiup Creek, Blue Mountains, OR. M.S. Thesis, University of Wisconsin, Madison. 107 p.

Coggins, George Cameron. 1984. The law of public rangeland management V: prescriptions for reform. Environmental Law 14(3): 498-545. Northwestern School of Law, Lewis and Clark College.

Cooper, J. L. 1978. A technique for evaluating and predicting the impact of grazing on stream channels. Transactions of the Bonneville Chapter of the American Fisheries Society, Salt Lake City, UT. February 3-4, 1978.

Cooperrider, Allen Y. 1986. Inventory and monitoring of wildlife habitat: habitat evaluation systems. USDI, Bureau of Land Management, Service Center, Denver, CO. *In* Cooperrider, Allen Y.; Boyd, Raymond J.; Stuart, Hanson R. (Eds.). Inventory and Monitoring of Wildlife Habitat. p. 757-776.

Cooperrider, Allen Y. 1986. Inventory and monitoring of wildlife habitat: evaluation and interpretation. USDI, Bureau of Land Management, Service Center, Denver, CO. *In* Cooperrider, Allen Y.; Boyd, Raymond J.; Stuart, Hanson R. (Eds.). Inventory and Monitoring of Wildlife Habitat. p. 777-783.

Cope, O. B. (ed.). 1979. Grazing and riparian/stream ecosystem forum proceedings. Trout Unlimited Inc., Washington, D.C. 94 p.

Crance, Johnie, K. 1988. Relationships between palustrine wetlands of forested riparian floodplains and fishery resources: a review. USDI, Fish and Wildlife Service, Biological Report 88(32). 27 p.

DeBano, L. F.; Heede, B. H. 1987. Enhancement of riparian ecosystems with channel structures. Water Resources Bulletin 23(3): 463-470.

Fagen, Robert. 1988. Population effects of habitat change: a quantitative assessment. Journal of Wildlife Management 52(1): 41-46.

Fajen, Otto F.; Wehnes, Richard E. 1981. Missouri's method of evaluating stream habitat. *In* Armantrout, Neil B. (Editor). Acquisition and Utilization of Aquatic Habitat Inventory Information. Proceedings of a Symposium held October 28-30, 1981, Portland, OR. p. 117-123.

Garcia, John C. 1985. A method for assessing the value of stream corridors to fish and wildlife resources. USDA, Forest Service, General Technical Report RM-120. p. 335-338. *In* Johnson, R. Roy et al. (Tech. Coords.). Riparian Ecosystems and their Management: Reconciling Conflicting Uses. First North Am. Riparian Conf. Tucson, AZ. April 16-18, 1985.

Gebhardt, K., M. Vinson, W. S. Platts, and W. Jackson. 1989. Using expert systems in riparian management. *In* Practical Approaches to Riparian Resource Management - An Educational Workshop. Billings, MT. pp. 187-189.

Gifford, Gerald F.; Hawkins, Richard H. 1976. Grazing systems and watershed management: a look at the record. Journal of Soil and Water Conservation 31(6): 281-283.

Gifford, Gerald F.; Springer, Everett P. 1980. A selected annotated bibliography on grazing hydrology. Utah Agricultural Experiment Station, Research Report 50. Logan, UT. 33 p.

Gregg, Ron 1978. A method for analyzing livestock impacts on stream and river riparian habitats. In: Graul, Walter D.; Bissell, Steven J. (Technical Coordinators). Lowland river and stream habitat in Colorado: a symposium. Symposium held at Greeley, CO, October 4-5, 1978. p. 89-99.

Gregg, Ron. 1979. A method for analyzing livestock impacts on stream and riparian habitats. *In* Cope, O.B. (ed.), Proc. of the Forum—Grazing and Riparian/Stream Ecosystems. Trout Unlimited, Inc., March 1979. p. 92-94.

Hall, James D.; Baker, Calvin O. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America. USDA, Forest Service, General Technical Report PNW-138. 29 p.

Hamilton, Karen; Bergersen, Eric P. 1984. Methods to estimated aquatic habitat variables. Colorado Cooperative Fishery Research Unit, 201 Wagar, Colorado State University, Ft. Collins, CO 80523.

Hays, Robert L.; Summers, Cliff; Seitz, William. 1981. Estimating wildlife habitat variables. USDI, Fish and Wildlife Service, Office of Biological Services, Report FWS/OBS-81/47. 111 p.
Heede, Burchard H.; DeBano, Leonard F. 1984. Gully rehabilitation - a three-stage process in a sodic soil. Journal of the Soil Science Society of America 48(6): 1416-1422.

Holechek, Jerry L. 1981. A brief history of range management in the United States. Rangelands 3(1): 16-18.
Holechek, Jerry L. 1983. Considerations concerning grazing systems. Rangelands 5(5): 208-211.

Holechek, Jerry L.; Timothy J. Berry, Martin Vavra. 1987. Grazing system influences on cattle performance on mountain range. Journal of Range Management 40(1): 55-59.

Hormay, August L. 1970. Principles of rest-rotation grazing and multiple-use land management. USDI, Bureau of Land Management and USDA, Forest Service. U.S. Department of Agriculture, Training Text 4(2200). September, 1970. Washington, D.C. 26 p.

Horton, Robert E. 1945. Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology. Bulletin of the Geological Society of America 56: 275-370. March 1945.

Jackson, W. L.; Van Haveren, B. P. 1985. Design for a stable channel in coarse alluvium for riparian zone restoration. Water Resources Bulletin 20(5): 695-703.

Johnson, R. Roy; Jones, Dale A. (Technical Coordinators). 1977. Importance, preservation and management of riparian habitat: a symposium. USDA, Forest Service, General Technical Report RM-43. 217 p. Rocky Mountain Forest & Range Experiment Station, Fort Collins, CO 80521. Symposium held in Tucson, AZ, on July 9, 1977.

Johnson, R. Roy; Ziebell, Charles D.; Patton, David R., Ffolliott, Peter F.; Hamre, R. H. (Technical Coordinators). 1985. Riparian ecosystems and their management: reconciling conflicting uses. USDA, Forest Service, General Technical Report RM-120. 523 p.

Johnson, Steve. 1984. Some useful quotes on grazing from various sources. Unpublished manuscript compiled by S. Johnson, Southwest Representative for Defenders of Wildlife. 10 p.

Kauffman, J. Boone; Krueger, William C.; Vavra, Martin. 1983. Impacts of cattle grazing on streambanks in northeastern Oregon. Journal of Range Management 36(6): 683-685.

Kauffman, J. Boone; Krueger, W. C. 1984. Livestock impacts on riparian ecosystem and streamside management implications. A review. Journal of Range Management 37(5): 430-438.

Kellerhals, Rolf; Church, Michael. 1980. Comment on "Effects of channel enlargement by river ice processes on bankfull discharge in Alberta, Canada" by D. G. Smith. Water Resources Research 16(6): 1131-1134.

Keown, Malcolm P. and others. 1977. Literature survey and preliminary evaluation of streambank protection methods: a final report. U.S. Department of Defense, Army Corps of Engineers, Waterways Experiment Station, Hydraulics Laboratory. Vicksburg, MS. Technical Report H-77-9. 258 p.

Kovalchik, Bernard L. 1987. Riparian zone associations of the Deschutes, Fremont, Ochoco and Winema National Forests. USDA, Forest Service, Pacific Northwest Region, R6-ECOL-TP-279-87. 171 p. [Available from: Wm. Hopkins, Area 4 Ecologist, Silviculture Laboratory, 1027 N. W. Trenton Ave., Bend, OR 97701, (503) 388-7434.]

Marlow, Clayton B.; Pogacnik, Thomas M. 1986. Cattle feeding and resting patterns in a foothills riparian zone. Journal of Range Management 39(3): 212-217.

VII-42 **Marlow, Clayton B.; Pogacnik, Thomas M.; Quinsey, Shannon D.** 1987. Streambank stability and cattle grazing in southwestern Montana. Journal of Soil and Water Conservation 42(4): 291-296.

Martin, S. Clark. 1979. Evaluating the impacts of cattle grazing on riparian habitats in the national forests of Arizona and New Mexico. In: Cope, O.B. (ed.), Proc. of the Forum—Grazing and Riparian/Stream Ecosystems. Trout Unlimited, Inc., March 1979. p. 35-38.

Milner, N. J.; Hemsworth, R. J; Jones, B. E. 1985. Habitat evaluation as a fisheries management tool. Journal of Fish Biology 27(Supplement A): 85-108.

Minshall, G. Wayne. 1985. Evaluation of stream riparian area conditions using benthic macroinvertebrates. Idaho State University, Department of Biology. Final Report for Cooperative Agreement No. 22-C-3-INT-50.

Morris, J. 1986. Evaluating the wetland resource. Journal of Environmental Management 24: 147-156.

Natural Resources Law Institute. 1986. Livestock grazing in riparian zones: ensuring fishery protection in federal rangeland management. Anadromous Fish Law Memo, Issue 37, October, 1986. Natural Resources Law Institute, Lewis and Clark Law School. Portland, OR.

Platou, Karen A.; Tueller, Paul T. 1985. Evolutionary implications for grazing management systems. Rangelands 7(2): 57-61.

Platts, William S. 1979. Livestock grazing and riparian/stream ecosystems—an overview, *In* Cope, O.B. (ed.), Proc. of the Forum—Grazing and Riparian/Stream Ecosystems. Trout Unlimited, Inc., March, 1979. p. 39-45.

Platts, William S. 1982. Livestock and riparian-fishery interactions: what are the facts? Transactions of the North American Wildlife and Natural Resource Conference 47: 507-515.
Platts, William S.; Nelson, Rodger L. 1985. Streamside and upland vegetation use by cattle. Rangelands 7(1): 5-10.

Platts, William S. 1989. Compatibility of livestock grazing strategies with fisheries. *In* Practical Approaches to Riparian Resource Management - An Educational Workshop. Billings, MT. pp. 103-110.

Platts, W. S. and R. L. Nelson. 1989. Characteristics of riparian plant communities and streambanks with respect to grazing in Northeastern Utah. In - Practical Approaches to Riparian Resource Management - An Educational Workshop. Billings, MT. pp. 73-81.

Platts, W. S., F. J. Wagstaff, and E. Chaney. 1989. Cattle and fish on the Henry's Fork. Rangelands 11:(2) 58-62.

Quigley, Thomas M. 1981. Estimating contribution of overstory vegetation to stream surface shade. Wildlife Society Bulletin 9(1): 22-27.

Price, D. G.; Adams, J. R. 1982. A fishery resource sampling methodology for small streams. Pacific Gas and Electric Report 420-81.141. 49 p.

Ratliff, Raymond D. 1985. Meadows in the Sierra Nevada of California: state of knowledge. USDA, Forest Service, General Technical Report PSW-84. 52 p.

Ray, Gary A.; Megahan, Walter F. 1979. Measuring cross sections using a sag tape: a generalized procedure. USDA, Forest Service, General Technical Report INT-47. Intermountain Forest and Range Experiment Station, Ogden, UT. 12 p.

Reichard, N. 1984. Riparian habitat restoration: some techniques for dealing with landowners, livestock, and eroding streambanks. In: Hassler, T. J., Editor. Pacific Northwest Stream Habitat Management Workshop. [Humboldt State University, Arcata, CA, October 10-12, 1984.] Pages 128-137.

Reiser, D. W.; Bjornn, T. C. 1979. Habitat requirements of anadromous salmonids. USDA, Forest Service, General Technical Report PNW-96. Portland, OR. 54 p.

Robinson, J. L. 1982. Development and testing of a stream morphology evaluation method for measuring user impact on riparian zone. M.S. Thesis, University of Wyoming, Laramie, WY.

Sather, J. H., R. D. Smith. 1984. An overview of major wetland functions. USDI, Fish and Wildlife Service, Office of Biological Services, Report FWS/OBS-84/18. 68 p.

Savory, Allan; Parsons, Stanley D. 1980. The Savory grazing method. Rangelands 2(6): 234-237.

Sedell, James R.; Luchessa, Karen J. 1981. Using the historical record as an aid to salmonid habitat enhancement. *In* Armantrout, Neil B. (Editor). Acquisition and Utilization of Aquatic Habitat Inventory Information. Proceedings of a Symposium held October 28-30, 1981, Portland, OR. pp. 210-223.

Short, Henry L.; Williamson, Samuel C. 1986. Evaluating the structure of habitat for wildlife. *In* Verner, J. et al. (Eds.). Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press. Madison, WI. Pages 97-104.

Skovlin, Jon M. 1984. Impacts of grazing on wetlands and riparian habitat: a review of our knowledge. *In* Developing Strategies for Rangeland Management. pp. 1001-1103. National Research Council/National Academy of Sciences. Westview Press. Boulder, CO. 2022 p.

Society for Range Management, Range Term Glossary Committee . 1974. A glossary of terms used in range management. Society for Range Management. M. M. Kothmann, Chairman. 36 p.

Theurer, Fred D.; Lines, Ivan; Nelson, Terry . 1985. Interaction between riparian vegetation, water temperature, and salmonid habitat in the Tucannon River. Water Resources Bulletin 21(1): 53-64.

U.S. Congress, Committee on Government Operations. 1986. Federal grazing program: All is not well on the range. Union Calendar No. 342. 99th Congress, 2d Session. House Report 99-593. Thirty-Fourth Report by the Committee on Government Operations Together with Additional and Dissenting Views. U.S. Government Printing Office. Wash., D.C. 74 p.

U.S. Fish and Wildlife Service. 1980. Riparian ecosystems: a preliminary assessment of their importance, status, and needs. USDI, Fish and Wildlife Service, Report W/COAL-80/W28. Western Energy and Land Use Team. Ft. Collins, CO. 55 p.

Wagoner, Ora. 1986. Inventory and monitoring of wildlife habitat: literature review. USDI, Bureau of Land Management, Service Center, Denver, CO. In: Cooperrider, Allen Y.; Boyd, Raymond J.; Stuart, Hanson R. (Eds.). Inventory and Monitoring of Wildlife Habitat. p. 29-47.

Wagstaff, Fred J. 1983. Evaluating proposed improvements of public rangelands. USDA, Forest Service, General Technical Report INT-150. Intermountain Forest and Range Experiment Station, Ogden, UT. 4 p.

Wald, Johanna; Alberswerth, David. 1985. Our ailing public rangelands: condition report - 1985. National Wildlife Federation and the Natural Resources Defense Council. Report.

Winter, Jimmy D.; Ross, Marvin Jon. 1981. Methods in analyzing fish habitat utilization from telemetry data. *In* Armantrout, Neil B. (Editor). Acquisition and Utilization of Aquatic Habitat Inventory Information. Proceedings of a Symposium held October 28-30, 1981, Portland, OR. p. 273-279.

Young, James A.; Raymond A. Evans; Richard E. Eckert, Jr. 1984. Successional patterns and productivity potentials of the sagebrush and salt desert ecosystems. *In* Developing Strategies for Rangeland Management. p. 1259-1300. National Research Council/National Academy of Sciences. Westview Press. Boulder, CO. 2022 p.

APPENDIX C - REVIEWERS

John Bartholow - Fossil Creek Software

Fort Collins, Colorado

Richard H. Braun - Attorney with Stoll, et al.

Portland, Oregon

Ed Chaney - Chinook Northwest, Inc.

Land Use Consultant

Eagle, Idaho

Pat Coffin - Nevada Department of Wildlife

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Karl Gebhardt - Consulting Hydrologist

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Hugh Harper - Retired BLM Range-Wildlife Specialist

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LeRoy McClelland - Nevada Department of Wildlife

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Regional Fisheries Biologist

Elko, Nevada

APPENDIX D - LAWS, REGULATIONS AND MANDATES RELATED TO RIVERINE-RIPARIAN MANAGEMENT

A partial listing of laws, regulations, and mandates that relate to the management and use of riverine-riparian systems and the products they produce:

1. Anadromous Fish Conservation Act of 1965 - P.L. 89-304
2. Bald Eagle Act of 1940 - P.L. 86-70
3. Clean Water Act of 1977
4. Endangered Species Act of 1973 - P.L. 93-205
5. Federal Land Policy and Management Act of 1976 - P.L. 94-579
6. Fish and Wildlife Coordination Act of 1934
7. Forest and Rangeland Renewable Resources Planning Act of1974.
8. Land and Water Conservation Fund Act of 1965 - P.L. 88-578
9. Multiple-Use Sustained Yield Act of 1968
10. National Enviromental Policy Act of 1969 - P.L. 91-190
11. National Forest Management Act of 1976
12. National Stripmine Act
13. Public Rangelands Improvement Act of 1978 - 95-514
14. Renewable Resources Extension Act of 1978 - P.L. 95-396
15. Resources Conservation Act
16. Sikes Act of 1960 - P.L. 86-797
17. Surface Mining Control Reclamation Act of 1977
18. Water Pollution Control Act of 1972 - P.L. 92-500
19. Water Resources Planning Act of 1965 - P.L. 89-90
20. Wild and Scenic Rivers Act of 1968 - P.L. 90-542

The BLM is understaffed and over-aged. Over-age builds maturity but it puts the "old-time-thinking" in power. The only scientific analysis of BLM philosophy that I know of was conducted on the Vale District. An evaluation of the Vale Rangeland Rehabilitation Program was conducted by Bartlome and Heady (1988). They interviewed 68 employees, which included all the employees on the Vale District.

They found that younger BLM employees (less than 9 years of service) more often believed than did older employees (over 9 years of service) that BLM wildlife-fisheries management needs improvement. Younger employees were twice as positive as older employees that BLM recreation management needs improvement. Newer employees were *much* less likely than longer-term employees (9 vs. 49 percent) to agree that livestock grazing is the best use of public lands.

This study demonstrated that the younger employees are taking a different approach to the management of public lands. They are well trained and can be good proponents of balanced land management.

What BLM Line Officers Consider

As with the Forest Service, the BLM has the responsibility to manage the habitat. Your and their responsibilities overlap. This overlapping offers a great challenge for you to work with their line officers in what they consider their kingdom. As in the Forest Service they must manage fish and wildlife habitat within the context of managing all resources. It is national policy to recognize the state management of resident species. They must initiate active cooperation with Nevada state agencies in all facets of their wildlife program. Their recommendations for wildlife habitat management will be based on state goals for resident wildlife populations. The protection, enhancement, and recovery of threatened and endangered species will receive priority consideration in all BLM activities. Migratory birds and the federally listed threatened and endangered species have become, at least in part, the responsibility of the federal government.

IN LAND USE MANAGEMENT, THERE IS A TENDENCY TO MOTHERHOOD, GENERALIZE, AND PROCRASTINATE

Line officers got where they are because they are team players and "company people." If they disagreed with old established practices, they were not team players. They usually consider first what has always proven good for the agency. The rules are changing somewhat, in that they must for the first time, begin to consider what is good for the public and the resource. The reluctance of the Bureau to allocate forage for wildlife, especially big game, is a prime example of the results of the team player approach. The current monitoring mode of the BLM is not beneficial to fisheries and wildlife, and until change occurs, these resources will not receive the recognition required to meet their demand for forage.

The BLM must have public support if it is to be a viable agency. The livestock user can no longer carry it through the political arena. You can use this to your advantage by contributing professional knowledge and integrity to resource management and thus gaining the needed public support. Do this in cooperation with the Area and District Managers. What makes them look good can also make you look good, but most important the wildlife-fishery resource will benefit. There is a real need to get the public more involved in BLM matters. It's such a busy world this is hard to do but it's worth the effort.

WORK TOGETHER -- THIS PUTS FEARS TO REST

Something that won't make you popular, but needs to be done anyway, is to get the BLM off the monitoring-holding ploy and on to doing something constructive on the ground. Most decisions should not be delayed any longer. There is more knowledge around today than the agency would like to admit.

Riparian Policy

The BLM knows how to restore and manage riparian habitats. There are no breakthroughs from research needed to guide good land management. The land is now dotted with representative successful projects that can be interpolated over broad land areas. There is nothing except person power, money, and commitment at the top standing in the way of the BLM putting its riparian policy into effect and beginning to reap the rewards.

The BLM Director, surprisingly, has signed off on a riparian policy to maintain, restore, or improve riparian areas to achieve a healthy and productive ecological condition for maximum long-term benefits. Each state has developed its own riparian management strategy. The policy and strategies call for achieving riparian area improvement under existing uses wherever possible. You can live with this as there are proven ways to do it under most circumstances.

The policy requires that any new or revised resource plans recognize and include the importance of riparian areas. NDOW specialists should make sure that land use plan objectives are site-specific. They must be measurable and achievable, and then the manager should be pushed to meet them. All management activities must be revised where site-specific objectives are not being met. This policy is strong medicine and it can constantly be used to your advantage if you understand it, know how to work with it, and urge its application. Also, each District is required to develop a riparian demonstration area, where BMP's and instream habitat repair projects will be demonstrated. You can not only help in identifying where these projects should be, but use them to demonstrate the benefits of good management. You should make sure, however, that stream repair projects do not get in the way of good land stewardship. All repair projects must be followed up and the results documented.

The need in Nevada for implementing the riparian policy is well justified by the BLM's own task force report on the condition of Nevada's ranges (BLM 1974). In summary the report states that:

1. Uncontrolled, unregulated, unplanned livestock use is occurring in approximately 85 percent of the state and damage to wildlife (including fisheries) habitat can be expressed only as extreme destruction.
2. Stream riparian habitat where livestock grazing is occurring has been grazed out of existence.

This report is as valid today as it was in 1974 as riparian areas have worsened instead of improving since this date.

Regardless of these findings, and if you have been doing your homework in reviewing the many BLM EIS's, you have found that there is little in these plans that will improve riparian habitats. We must all ask ourselves where we were when we were so badly needed to set the record straight during the EIS process. Many groups are still skeptical of the BLM's overall commitment to riparian management.

A positive note is the Fisheries Goals and Objectives under "Fish and Wildlife 2000" that evolved as a result of the riparian policy. The goal of this report is to establish the direction needed for management of riparian areas so as to achieve healthy and productive conditions for long-term benefits and values. Of course it has to done in concert with the range and watershed programs. A new BLM Director has just come on board who appears at this time to look upon this new effort with favor.

Objectives of the program are to implement current land use plans for species or habitats identified as important to local communities. Of course it must be done within time frames established by BLM managers. Emphasis is placed on coordinated management approaches for fish species and their habitats, where needs have been identified through the BLM land use planning process, or by cooperating agencies. The program calls for maintaining or enhancing important fisheries resources by implementing habitat management or improvement projects identified during the planning process, but in accordance with priorities established by management. By now you can see there are some bureaucratic safety valves and constraints attached to the goals and objectives and this is where you can help the program out -- by seeing that management puts these goals and objectives in their true order of importance.

The FY 1986, 1987, and 1988 Annual Work Plan Directives to field offices established management of riparian/wetland areas as one of the highest priorities in BLM fish and wildlife, watershed, and range management programs. This is strong direction that has not often come from the top. It may be a sign of change. If so, it can only increase the riparian consciousness among BLM resource specialists, an outlook that is especially needed in managers. Now is the time for strong management commitment and support.

Legal Requirements

There are at least 30 legislative acts, six Executive Orders and several Bureau manual sections that provide direction to BLM for the management of riparian aquatic resources on public lands. Lack of legal backing to conduct proper land management is not a constraint. The basic legislative authority for carrying out the grazing program is the Taylor Grazing Act, passed way back in 1934. The purpose of the Act, to stop the degradation of the Nation's ranges, was very timely. Because there were no advocates in the mid-1930's for wildlife and fisheries, the nearly sole objective of the Taylor Grazing Act was to stabilize the livestock industry. All resulting policies and regulations were developed between the livestock industry and the BLM alone.

The Act called for little planning and hardly any took place the first two decades after passage. Fishery, wildlife, and watershed values were usually always ignored in decision making. The Taylor Grazing Act was purposely drafted to mesh with the custodial phase of livestock management and to guide the adjudication stage. The Act was not advanced enough in new thinking to guide the BLM through the intensive management stage of the 1960's and 1970's. Therefore, it completely failed the environmental phase of the 1980's. The Act is now outdated and should be done away with. It is slowly being replaced by such legislation as the Federal Land Policy and Management Act of 1976. Probably the most significant results of the Taylor Grazing Act were the elimination of transient livestock herds and the establishment of administrative districts and livestock grazing allotments.

The Federal Land Policy and Management Act (FLPMA)

With the passage of FLPMA, the BLM received for the first time, permanent authority to retain and manage fisheries and wildlife in multiple use management. The Act, now over a decade old, remains the basic guide for management of fish and wildlife habitat on BLM lands. It places fish and wildlife on an equal footing with all other uses, requires that fish and wildlife needs be considered in all land exchanges, and authorizes designation of "Critical Areas of Environmental Concern." The Act establishes that livestock grazing should be on an equal footing with wildlife and fish in all planning and decision making. Section 401 (b)(1) of the Act authorizes the use of range betterment funds for the protection, maintenance, rehabilitation, improvement, and management of wildlife habitat. Wildlife and fisheries habitat must also be protected pursuant to the management prescriptions specified in Resource Management Plans (RMP's) and Habitat Management Plans (HMP's).

FLPMA required the BLM to conduct inventories of all public land resources. It must prepare comprehensive land use plans that include fish and wildlife as equal uses. FLPMA also requires BLM to prepare Environmental Impact Statements on all major actions that could affect the environment. FLPMA is now about 12 years old but it has not resulted in any measurable improvement in riverine-riparian lands.

FLPMA requires monitoring of land use plans. BLM policy is to complete rangeland monitoring and issue grazing decisions within

5 years after completion of an EIS. The 5-year period is almost over for many areas. This means the "time out period" is over and it is time for the BLM to "fish or cut bait." Because all grazing actions must now conform with existing land use plans, interested parties should obtain land use plans and review them for consistency with management actions. The plan should identify the issues grazing decisions should address. Participate in on-the-ground reviews and identify those areas where grazing decisions are not in compliance with wildlife and fisheries needs. Also, early in the game ask them to describe what management objectives will be monitored, what monitoring methods will be used, and how the monitoring is to be done. The BLM does not have the capabilities (funds and physical resources) to conduct the required level of monitoring and evaluation. This puts them in a poor position and I feel sorry for them, but the law is the law. They must give equal consideration to fish and wildlife habitat in all decision making and follow up with appropriate management. They should not continue to degrade riverine-riparian resources.

As stated before, the first thing to do is identify the decision maker. Often that person will stay way in the background and let the staff bear the brunt of the public contact. Once the decision maker has been identified, keep on good terms with him or her. Remember it's a tough job to mesh lawful mandates of the multiple use politics with everyday living. Your job is to simply see that they abide by their mandates. They have to face the political consequences.

Public Rangeland Improvement Act (PRIA)

PRIA, passed in 1978, nominally supplements FLPMA and reaffirms the position and authority of grazing advisory boards, and long-term leases for grazing permittees. The "McClure Amendment" to the 1979 appropriations for this Act didn't make the job any easier. This amendment restricted any reduction in the numbers of animals permitted to graze an allotment to 10 percent annually irrespective of what was contained in the EIS. This may come back to haunt us, but the move to proper rangeland management can often be done without any reduction in livestock numbers. It is mostly just a matter of finally getting and maintaining some proper management on the ground. Good management seems to come in infrequent pulses with poor management filling the voids. There have been some good programs put into effect, but with continued changes in livestock programs and personnel or loss of support from the top, good programs have often gone by the wayside. A good example was the BLM'S Vale Project in Oregon. This was a good project and much was accomplished about 15 years ago. This project may have siphoned off more money than the BLM has put into any other single project, but it was successful. Then commitment and funding dried up and today the Vale Project riparian habitats are in shambles.

Working with the NEPA Process

The 1967 National Environmental Policy Act provided the major impetus for hiring fisheries biologists and some wildlife biologists in the BLM. This required for the first time that the BLM conduct Environmental Assessments of its issuance of livestock grazing licenses, their land management plans and other actions. The BLM must make a concise record of any decision coming out of the NEPA process. You should check this record on all major actions affecting fisheries-wildlife resources, and make sure they were adequately addressed in the planning process. NEPA has been in effect for about 20 years now and it has been recorded that BLM rangelands have improved by only 1 percent during that period. This exemplifies that the rehabilitation of riverine-riparian habitats will require something different than what has been done in the past. The NEPA process, implemented adequately and with follow-up decisions and monitoring, can bring about the necessary changes.

EIS's

The BLM has had a massive program of preparing court-ordered EIS's since the early 1970's to assess the impacts of livestock grazing. The inventories may have been quite good but the end results have had little effect. The BLM has never had the full multiple-resource inventories, however, to properly assess existing resources. Therefore, forage allocations and other key decisions affecting wildlife-fisheries are mainly incomplete or "business as usual." Help them out whenever you can with your data base and also input into their decision making.

Other Acts

Two other acts play an important part in the BLM's wildlife-fisheries program. The first is the *Sikes Act* in which Congress mandated the BLM to plan, develop, maintain, and coordinate programs for the conservation and rehabilitation of fish and wildlife habitats. The Sikes Act was never funded adequately, but what money did come down the pike was utilized for the development of habitat management plans in cooperation with the states. You should be brought in on any of the planning and implementation stages -- if you are not, find out why. The Sikes Act requires cooperative BLM-state efforts for the conservation and rehabilitation of wildlife-fisheries resources on the public lands. Cooperative agreements have already been signed with NDOW.

The second act is the *Endangered Species Act* which provides for the protection of listed and potentially listed plant and animal species and their habitats. Many of the listed fish species in the West are on BLM lands, and Nevada has its share.

The BLM has two major responsibilities under this Act. One is to seek means to ensure recovery of listed species on BLM lands. The other is to ensure that any federal action authorized, funded, or carried out (including livestock grazing) is not likely to jeopardize the continued existence of T&E species or result in destruction or adverse modification of critical habitat. The mandatory requirements of the Endangered Species Act have the potential for imposing major constraints on other uses of the public lands. There is usually little managerial discretion for carrying out any program that conflicts with T&E objectives.

Executive Order (EO) number 11990 made in 1977 directs federal agencies to minimize the destruction, loss, and degradation of wetlands and to preserve and enhance the beneficial values of wetlands. EO number 11988 made in 1977 instructs all federal agencies to restore and preserve the natural and beneficial values of floodplains.

Executive Orders and Policy Statements

Executive Orders and Policy Statements also require the BLM to manage fish and wildlife resources within a multiple use framework without any long-term loss of habitat capability. Special attention is given to aquatic resources with unique values. Direction for the management of fisheries and wildlife habitat is identified in the BLM's land use planning process. Land use decisions are implemented on the ground through site-specific plans and through fish and/or wildlife habitat management plans. Monitoring and evaluation are an essential part of all plans.

Protests and Appeals

All land use plans can be appealed. You will seldom enter into this process, as your major responsibility is to make sure that the land use plans are adequate in the first place. Because the public will be appealing land use plans you should understand the appeal process and what influences it could have on wildlife-fisheries resources. Study the BLM's planning regulations. Every Forest Plan has been appealed. The appeal process is slow but almost always gives the managers a different, valuable perspective on their decisions.

Appeals to BLM plans are filed with the State Director with a copy to the respective Field Solicitor. Reasons for the appeal must be stated, and appellants must have participated in the planning process to qualify for an appeal. The Director's decision is final on this appeal and if you are not in agreement with his or her decision, the only recourse is to take it out of administrative appeal and into the courts. These actions can be costly in time and money and can influence your management time schedules.

Monitoring

In 1980 the BLM, because of its large problem with preparation of EIS's and the public concerns over "one time inventories" went into a 5-year monitoring program. There was great animosity building in Nevada on the BLM's approach to making livestock reductions. The change in direction to monitoring was supposedly to provide a consistent supportable approach to making management changes and improve the working relationships with other entities. The BLM worked with the Nevada Range Studies Task Group to cooperatively develop a consistent, technically adequate, and cost-effective set of rangeland monitoring procedures for approximately 46,000,000 acres of BLM-administered public land in Nevada. It is now ten years later, and undoubtedly, the rangeland is in as poor shape now as it was then. There may have been some procedures developed that could change this situation. Time will tell, but the public should not put up with this situation forever.

The monitoring procedures in the "Nevada Rangeland Monitoring Handbook" are supposedly sound and can be implemented into the coordinated planning approach used on each BLM District. The state BLM office staff reviews the processes used on the ground and supposedly makes sure coordinated planning is consistent and technically sound. Managers must still evaluate present management at the allotment level to determine if land use planning objectives are being met. The approach appears to be sound but the proof of the pudding is in performance and needed results. Your work on evaluating wildlife-fisheries habitats will serve to prove if present or proposed management will accomplish wildlife-fisheries objectives. You should constantly share your findings with them to demonstrate if progression toward established objectives is being made. During 1987 and 1988 in Nevada, it is doubtful if any betterment resulted in riverine-riparian habitats because of climatic conditions. Hopefully just after the turn of this decade we will notice some improvement. If not, it's back to the drawing boards for all managers.

Allotment Management Plans

In the 1960's the BLM adopted the concept of "Allotment Management Plans" (AMPs). (See also the section on Allotment Management Plans under "Working with the Forest Service," p. III-18.) The plans are written in consultation with affected permittees. In the beginning the plan was simply an application of some type of grazing strategy designed around some recognized physiological requirements of the livestock's key forage species. In the early 1970's some AMPs were challenged because they accomplished livestock management objectives but failed to meet other resource objectives.

AMP's levels of grazing use for livestock were monitored on the basis of Class 1 grazing privileges and range condition and trend. Unfortunately the well-being of wildlife-fisheries resources has often not been adequately incorporated into condition and trend of livestock management objectives. This is especially true if management objectives are only established and monitored in the uplands. The plan calls for a description in detail of how the grazing operations are affecting fish, wildlife, watershed, and recreation values. It is very key that you obtain and read this portion of the plan. The first thing to do is look for land use plan objectives. You will find that most plans are outdated. Plans were put together with only the permittees' input, and many were developed without consideration for other resource values.

If the plan is not adequate, request that an updated AMP be completed under an interdisciplinary approach. The famed BLM Nevada Report (1974) found the majority of their AMP's failed to adequately identify or specifically provide for non-livestock resources. It is your fault if the BLM in your area continues to allow livestock grazing under out-of-date AMP's. You can make a difference, especially when you keep pointing out that grazing levels in an allotment are at the upper reaches of of proper utilization. Thus, when natural events such as drought or grasshopper infestations occur, there is no "safety valve" and almost always the range suffers, but the non-livestock grazing resources and values suffer first and most.

One of the most key things you can do at the outset is to insist that the BLM use ungrazed allotments to take pressure off problem allotments. When an allotment is in need of rehabilitation, fire wipes out a forage producing area, or low precipitation years just do not produce the forage necessary to prevent overgrazing, then the ungrazed allotment could be utilized until the other allotment is rehabilitated. This nonuse principal goes against the whole philosophy of BLM thinking, but it would do more good for wildlife-fisheries resources than anything else we could do at this time. When an allotment goes into nonuse or is given up -- jump on it and request that BLM set it aside for rehabilitating other allotments with problems. Everyone knows there will always be problem allotments in the future. It's time the BLM created some safety valves to take the pressure off.

The BLM has an Allotment Management Handbook that you should become familiar with. Review this handbook before you participate in the review of any allotment in your area. State and District Office staffs are required to conduct occasional quality control field reviews in selected Resource Areas. You can be part of this procedure by asking to participate on the evaluation team.

A Strategy for the Future

In 1987 the BLM Director approved a program "Fish and Wildlife 2000: A Plan for the Future," developed mainly internally by BLM personnel. It's a good document and sets forth goals and objectives for more effective management of fish and wildlife resources. There are some real pluses in this program that if carried through would benefit your working relations with the BLM, and more importantly benefit the fishery resources. "Strategy for the Future" calls for a strong partnership with state fish and wildlife agencies. You should use this to your mutual advantage. Never have wildlife-fisheries on BLM-administered public lands received their fair share of consideration and if this program can increase their share, it is worthy of your support. The BLM has started off running on many occasions, but never finished. Your input can help this program make it to the finish line.

The Fisheries-Wildlife Manual

The BLM, like the Forest Service, is undressed when not surrounded with its manuals. Their manuals are used constantly for direction and to guide implementation. Sections 6500 to 6900 pertain to the management of fish and wildlife. These sections should be on your bookshelf for constant review, and can be acquired from the District wildlife staff or the wildlife staff in the State Office. This manual requires the BLM to work closely with you. You should not receive any surprises from them and if you do, you should refer them back to their own manual. In addition, the BLM has handbooks and other guidance material which is outdated.

PEOPLE DO NOT DETERMINE WHO IS DOING A GOOD JOB -- THE LAND REVEALS WHO IS DOING A GOOD JOB

Nevada BLM has an NSO manual supplement #6672 on stream surveys you should be familiar with. Because livestock grazing is so widespread, you should be familiar with their grazing regulations, 43 CFR-4100. Often the BLM does not follow these regulations and gets away with it because no one else is tracking the results.

Do not depend on the BLM to have proper manual and guidebook guidance -- as with the Forest Service, it's just not there. The Forest Service may ignore its abundant guidance direction but the BLM always has sufficient guidance to ignore. This is one area you could improve by working your regional wildlife-fishery needs into their coming guides.

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